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C & R-PREP.

3a A Preliminary Summary of

Progress and Plans //

3° DECIDUOUS FRUIT AND TREE NUT RESEARCH

of the United States Department of Agriculture
and

in cooperation with
State Agricultural Experiment Stations; +3a

Prepared for the Department's
DECIDUOUS FRUIT AND TREE NUT RESEARCH AND MARKETING ADVISORY COMMITTEE

For its 12th Annual Meeting
East Lansing, Michigan
January 16-20, 1961

.....
This progress report is primarily a tool for use by advisory committee members in developing recommendations for present and future research programs and by USDA administrators for developing, coordinating, and evaluating research plans. Included in it are summaries of research done during the past year. Some are tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to advisory committee members, research administrators, and others having special interest in the development of public agricultural research programs.
.....
The report also lists publications of research results issued during the year. Current agricultural research findings are also reported in the monthly USDA publications, "Agricultural Research" and "Agricultural Marketing."
.....

2 UNITED STATES DEPARTMENT OF AGRICULTURE //
5a Washington, D. C.

FUNCTIONS OF ADVISORY COMMITTEES

The Deciduous Fruit and Tree Nut Committee is one of twenty-four commodity and functional committees of the U. S. Department of Agriculture established pursuant to Title III of the Research and Marketing Act of 1946. Functions of the members of these committees include:

1. Acquainting themselves with the problems of producers, processors, distributors, and consumers, and presenting them for committee consideration.
2. Reviewing the current research and marketing service programs of the Department and recommending adjustments, including terminations, in the current program in order that available funds, personnel, and facilities will be used on problems of greatest importance.
3. Recommending new work or expansion of current work and indicating relative priority of such recommendations, when the current program is insufficient to develop solutions for important problems.
4. Developing a better understanding of the nature and value of the agricultural research program, explaining it to interested groups and organizations and encouraging the wider and more rapid application of the findings of research.

The committees perform an important function in advising with respect to the development of the Department's research and marketing service programs. However, committee members recognize that the development of budgets and the implementation and administration of research and marketing programs are responsibilities of the Department.

A progress report similar to this one is prepared for each committee. The areas of the other twenty-three committees are:

Citrus and Subtropical Fruit	Oilseeds and Peanut
Cotton and Cottonseed	Potato
Dairy	Poultry
Economics	Refrigerated and Frozen Products
Farm Equipment and Structures	Rice
Food and Nutrition	Sheep and Wool
Food Distribution	Soils, Water and Fertilizer
Forage, Feed and Seed	Sugar
Forestry	Tobacco
Grain	Transportation
Home Economics	Vegetable
Livestock	

This progress report was compiled by Roy Magruder, Executive Secretary, Deciduous Fruit and Tree Nut Research and Marketing Advisory Committee, Office of Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

CODES TO DESIGNATE UNITS CONDUCTING RESEARCH

AGRICULTURAL RESEARCH SERVICE (ARS)

Farm Research Divisions

AE	. . . . .	Agricultural Engineering
ADP	. . . . .	Animal Disease and Parasite
AH	. . . . .	Animal Husbandry
CR	. . . . .	Crops
ENT	. . . . .	Entomology
FE	. . . . .	Farm Economics
SWC	. . . . .	Soil and Water Conservation

Utilization Research and Development Divisions

EU	. . . . .	Eastern
NU	. . . . .	Northern
SU	. . . . .	Southern
WU	. . . . .	Western

Home Economics Research Divisions

CH	. . . . .	Clothing and Housing
HHE	. . . . .	Household Economics
HN	. . . . .	Human Nutrition

AGRICULTURAL MARKETING SERVICE (AMS)

Economics Statistics Divisions

AEC	. . . . .	Agricultural Economics
AES	. . . . .	Agricultural Estimates

Marketing Research Divisions

MD	. . . . .	Market Development
ME	. . . . .	Marketing Economics
MQ	Market Quality
TF	Transportation and Facilities

FCS	FARMER COOPERATIVE SERVICE
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FAS	FOREIGN AGRICULTURAL SERVICE
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FOREST SERVICE (FS)

Forest Research Divisions

FDR	Forest Diseases
FER	Forest Economics
FFR	. . . . .	Forest Fire
FIR	. . . . .	Forest Insect
FMR	. . . . .	Forest Management
FPR	Forest Products Utilization
RMR	Range Management and Wildlife Habitat
WMR	Watershed Management

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I. FARM RESEARCH

A. Breeding and Genetics

1. PLANT INTRODUCTION AND DEVELOPMENT

CR

Problem: Introduce and initially evaluate deciduous fruits and tree nuts from foreign sources that may be of value as varieties, rootstocks, or breeding materials for this country.

Program: A continuing program involving surveying the literature from other countries, in some cases sending plant specialists to those countries to study and collect material and bringing to the United States material of possible value. In the United States, new material after quarantine and evaluation at Federal Plant Introduction Stations is sent to Federal and State research workers interested in it. The equivalent of 3.0 professional man-years are required for the deciduous fruits and tree nuts aspects of introduction and development.

Progress: The following 146 introductions of deciduous fruits and tree nuts were made during the year:

<u>Species</u>	<u>Number of Introductions</u>	<u>Source</u>
<u>Castanea crenata</u>	1	Korea
<u>Corylus avellana</u>	13	Spain, Sweden, The Netherlands
<u>Crataegus azarolus</u>	2	Italy
<u>Diospyros lotus</u>	6	Korea
<u>Juglans</u> spp.	24	Korea, Soviet Union
<u>Malus sylvestris</u>	32	Denmark, England, Latvia, Germany, Turkey, Yugoslavia
<u>Prunus</u> spp.	38	Argentina, Iran, England, France, Italy, Japan, Korea, Latvia, Soviet Union, Thailand
<u>Pyrus</u> spp.	30	England, Japan, The Netherlands, Yugoslavia

Many of the items were introduced to satisfy special requests from research workers. Examples are Corylus for evaluation in Oregon and both pome and stone fruits for workers in various parts of the country conducting research in virus diseases of these fruits.

The backlog of stone fruit introductions awaiting virus indexing while in quarantine has been reduced by the release of 8 cherry clones. However, several years work will be required before indexing of the 545 stone fruit clones remaining in quarantine can be completed. New introductions of stone fruits as vegetative material are not recommended until the backlog can be substantially reduced. The possibility should be explored of speeding up this work by releasing groups of introductions to interested research workers in state experiment stations for virus indexing under special post-entry quarantine permits.

Evaluation has been completed of foreign walnut introductions at Chico, California. Seed of Pistachia atlantica was sent to 43 cooperators and seed of P. terebinthus to 36. Both species appear to perform satisfactorily as rootstocks for grafting the pistachio nut, P. vera, in California. Budwood of pistachio nut varieties was sent to 16 individuals during the year.

Flowering, pollination, and seed development studies of the Chinese jujube, Zizyphus jujuba, carried out at Chico, California, were completed in 1959. These studies have shown that although the blossoming season of the jujube is very long, the life of individual flowers is quite short and many flowers apparently are not pollinated during their receptive period. Cross-fertilization appears to be necessary for the development of viable seed kernels and many of the aborted kernels observed among jujube seed apparently are the result of self-fertilization. As a result we now know that where either fruit or viable seed is desired, it is advisable that more than one clone be planted.

Plans: Descriptions of the Persian walnut introductions recently evaluated at Chico, California will be published in multilith forms for use of research workers in this field. A cooperative experiment to evaluate Pistacia species as rootstocks for nut varieties of the pistachio is being started at Fresno, California. More information is needed on the performance of both the nut varieties and rootstock combinations in this area of the State.

2. APPLE AND PEAR BREEDING AND VARIETY EVALUATION

CR

Problem: Develop new varieties of apples with better quality, suitable to the various areas, resistant to apple scab for the north central and eastern states, more winter hardy for the northern prairies, and with black rot resistance and early maturity for southeastern United States; develop new, high quality varieties of pears resistant to fire blight suitable for areas east of the Pacific Coast; evaluate and determine the relative merits of new varieties and sports of old varieties of pears and apples.

Program: A long-term research program to incorporate scab resistance with quality in new apple varieties and fire blight resistance into high quality pears; to develop cold-hardy high quality pears and apples, and early maturing, high quality apples for the southeastern United States. Work is located at Federal stations at Beltsville, Maryland; Mandan, North Dakota; and in cooperation with the Indiana Agricultural Experiment Station at Lafayette, Indiana; Washington Agricultural Experiment Station at Wenatchee, Washington; and the Georgia Agricultural Experiment Station at Blairsville, Georgia. Work will involve between two and three professional Federal man-years annually.

Progress: At Beltsville, Maryland, 3 new pear varieties have been named and introduced: Magness, a high quality dessert pear, also suitable for baby food, Moonglow, a high quality dessert and processing pear, and Dawn, a Bartlett-type pear which matures earlier than Bartlett. Magness and Moonglow are highly blight resistant and probably can be grown in much of the area suitable to apples in central and eastern United States and in which other high quality pears cannot now be grown because of fire blight. Dawn was introduced primarily because of its higher dessert quality and earlier maturity than Bartlett. It is slightly more blight resistant than Bartlett but should not be grown in areas not suitable to Bartlett. The introduction of these pears marks the first stage of accomplishment in this project. More progenies are being evaluated and even better pears are in the making.

At Beltsville, Md., an attempt has been made to obtain desirable characters in various fruits through doubling of the chromosome numbers through the use of colchicine. The Stayman Winesap apple is of no use as a parent because as a triploid it has an odd number of chromosomes, hence cannot give paired gametes upon reduction division. By doubling the chromosome number as a hexaploid, it can become a parent useful in producing tetraploids when crossed with diploids. In so doing, it may be possible to utilize some of the very desirable flavor and quality of Stayman in progenies. In preliminary attempts, distortion of leaves on colchicine treated trees indicate some effect. Cytological studies are in progress to determine what has happened.

In Indiana, in cooperation with the Agricultural Experiment Station, work has continued on breeding of apples for scab resistance. Progenies representing the third backcross from the original scab resistant parents are approaching the size, color and quality of commercial susceptible varieties. The work is necessarily slow requiring several years per generation but has proceeded much faster than anticipated. The work is regarded with extreme promise - some selections are ready for orchard testing.

At Mandan, N. D. a long-term study is under way to find or produce apple varieties of good quality which have both drought resistance and winter hardiness. Approximately 470 apple varieties

(including crabs) and 57 pear varieties are in the study. Several selections appear to stand out over the others and are being given a second test.

At Wenatchee, Wash., studies have been continued to evaluate the most promising color sports of apples. These studies involve such factors as yield, quality, color and in addition such factors as effect of early color in influencing immature harvesting. These have been propagated on Malling VII so that they can be evaluated under comparable conditions.

At Blairsville, Ga., a parent stock orchard has been planted, some preliminary progenies produced at Blacksburg, Va., in cooperation with the Virginia Agricultural Experiment Station, have been planted. Considerable effort has been expended to obtain possible parents which mature fruit early and which have a moderate to short chilling requirement.

Plans: Work will be continued along the same lines at all stations and at the same levels except at Beltsville where the pear breeding will be increased.

Publications:

Nature of plant sports. Haig Dermen. The American Horticultural Magazine. 39:123-173. 1960

The spur type Delicious. L. P. Batjer and E. S. Degman. The Goodfruit Grower, January 23, 1958.

New red sport apples. L. P. Batjer and E. S. Degman. Western Fruit Grower, February 1957.

3. PEACH AND OTHER STONE FRUIT BREEDING AND VARIETY EVALUATION CR

Problem: Develop new peach, cherry, plum and nectarine varieties with better fruit quality, attractiveness and firmness for a continuous succession of ripening throughout the season and adapted to climates in the various peach growing areas of the United States. Also develop nematode resistant rootstocks.

Program: A long-range program of basic studies as well as hybridization and testing is conducted at Federal stations at Fort Valley, Ga.; Mandan, N.D.; Beltsville, Md.; Fresno, Calif.; and also at Prosser, Wash., in cooperation with the Washington Agricultural Experiment Station. Valuable cooperation is maintained with many state experiment stations in evaluation of selections and new varieties. Work involves approximately 3 professional Federal man-years.

Progress: Two new sweet cherry varieties, Chinook and Rainier were named and introduced in 1960, in cooperation with the

Washington Experiment Station. A new peach variety, Earlired, was introduced at Beltsville, Md. The Chinook has dark colored, attractive, large firm fruit, ripening about a week before Bing. The Rainier fruit is light colored, large, firm and ripens a few days earlier than Napoleon and trees are especially winter hardy. The Earlired peach is a very early maturing, attractively colored fruit with firm, yellow flesh.

Peach breeding was continued on a major scale at Federal stations at Beltsville, Md.; Fresno, Calif.; Fort Valley, Ga. and in cooperation with the Washington Agricultural Experiment Station at Prosser, Washington. During 1960, approximately 10,000 peach and nectarine seedlings from controlled crosses were fruited and evaluated. In addition, further evaluation was made on approximately 500 more promising selections from the original seedlings. Additional crosses, based on detailed genetic information on parents, were made at each breeding location. New varieties originated at state experiment stations, nurseries, private growers, or breeder, and our own, were carefully evaluated at the different Federal stations.

At Fresno, Calif. plum breeding for both dessert and processing has resulted in several promising selections this year. Selections of the Queen Ann type but ripening both earlier and later than Queen Ann are especially promising. At Prosser, four domestica type prune-plum selections were made in 1960 and propagated for further test.

Breeding for winter hardy cherries and plums suitable to the Great Plains was continued at Mandan, N.D. Several especially promising seedlings were selected in 1960. Larger size and better quality have been combined with hardiness in several of the selections using Manchu and Korean type cherries as parents. Although these parents are listed as cherries, they hybridize well with plums.

At Fresno, Calif. and Prosser, Wash., apricot breeding and testing has been continued and shows encouraging results. Extension of the ripening season with large, high quality, early ripening varieties now seems very likely soon. Also resistance to pit-burning (heat injury) has been found among some of the more promising selections. Processing tests are also conducted on the selections to determine their relative value for canning purposes.

Studies to develop nematode resistant peach rootstocks have been continued at Fort Valley, Ga.; Fresno, Calif.; and Beltsville, Md. Crosses were made using previous nematode resistant progenies as parents crossing them with even more resistant species. In addition to nematode resistance a rootstock parent must transmit this character uniformly to its seedlings which must also be good rootstocks from the standpoint of crop production and production of good type, thrifty, winter hardy trees. The nematode resistance

of the seedling progenies is tested by exposure both in the field to naturally occurring populations and in the greenhouse to pure cultures of the nematodes. A selection made at Fort Valley several years ago and introduced under the number FV 234-1 continues to show value as a stock in recent commercial tests. It is resistant to both the acrita and Javanese strains of the root knot nematode.

Plans: Work on breeding of apricots, cherries, plums, peaches and nectarines will be continued on the present rate to obtain basic information on the inheritance of principal characteristics which can be used in future breeding work. Emphasis will be continued to combine quality, attractiveness and firmness with disease resistance and hardiness in varieties ripening successively over the season. More emphasis will be put on apricot breeding to obtain superior size for the canning industry and on the so-called "cherry Plum hybrids" to obtain better size in the hardy fruits for the Great Plains.

Publications:

Longer peach season. A. L. Havis. American Fruit Grower, February 1960. pp. 36-40.

Chinook and Rainier - new cherry varieties. Washington Agricultural Experiment Station Circular 375. August 1960.

The peach variety situation in the Pacific Northwest. H. W. Fogle. Proc. Washington State Hort. Assn. 55:52-55. 1959.

Peaches for canning and freezing: New freestones for West Coast Processors. H. W. Fogle. Canner/Packer Magazine. August 1959.

Sources of propagating wood for peach and nectarine varieties in the United States and Canada. K. W. Hanson, L. Whitton, H. W. Fogle, R. M. Peterson and H. W. Young. Fruit Varieties and Hort. Diges. 13(1):6-16. 1958.

Earlired. Naming and releasal of a very early peach variety. Crops Research Division releasal notice to fruit growers and nurserymen. August 1960.

4. BERRY AND GRAPE BREEDING AND VARIETY EVALUATION

CR

Problem: Originate improved varieties of berry and grape crops of high quality adapted to the various sections of the United States with emphasis on red stele-resistant strawberries for fresh market and processing; black-rot resistant bunch grapes; seedless grapes; self-fertile muscadine grapes; cold-hardy blueberries; blueberries with short chilling and cane-canker resistance; disease-resistant raspberries; and thornless blackberries. In

addition, conduct basic studies on inheritance of characters, breeding behavior of parental material for economic characters, and interspecific hybridization for disease resistance.

Program: A continuing program of basic research and applied plant breeding located at Federal Stations at Beltsville, Md.; Fresno, Calif.; Meridian, Miss.; Cheyenne, Wyo.; and formal cooperation with state stations in North Carolina, Oregon, Maryland, New Jersey and southern Illinois University at Carbondale; involving 5 professional man years, annually. Informal cooperation is conducted with many state experiment stations, nurserymen, and growers.

Progress: Blueberry breeding. In New Jersey, 40 new selections were made. Six advance-test selections were outstanding in heavy production when most commercial varieties were unproductive. These are G-71, G-72, G-103, 57-121, E-66, and G-90. G-90 ripens 2 weeks later than Coville and appears worth introducing if its fruits prove firm enough. Examination of 10 different characters in about 500 drought-resistant species hybrids combining V. ashei, tenellum, and australe parentage indicated a wide variation in characteristics. Fruit color was mostly dark and the size small, though a few scored very good in color and up to 18 mm in diameter. Scars and firmness were excellent in most seedlings. Bush types varied from dwarf through spreading to tall, upright plants. Plants were selected for use in further breeding for drought resistance.

At Jonesboro, Me., 23 new selections were made in the winter-hardy material. Four of the most promising winter-hardy, productive selections (Me-US-1-13, 1-24, 1-27, and 1-35) have been propagated for testing further.

In the rabbiteye type blueberry breeding for southeastern United States, the T-1 selection at Tifton, Ga., has appeared promising for several years and plans have been made for its introduction as an early (for rabbiteye) variety. Its plants are very productive, of light blue, medium-sized fruit satisfactory for processing. T-38, T-14, and T-7 have had the highest yields in a replicated test at Tifton, which included all the recently named varieties. When 200 seedlings of complex interspecific parentage involving V. ashei, V. tenellum, and V. australe were evaluated for season, size, color, and vigor, most earliness occurred in a progeny of G-52 x US-38, largest size in US-34 x Tifblue, which also had the most blue-fruited seedlings and the most vigorous plants. Poorest vigor occurred in seedlings of US-39 x US-37, probably due to too high chilling requirements of the plants.

In North Carolina, cane canker in some commercial fields has become severe on Wolcott, a variety considered a canker-resistant type. New seedling selections from progenies of Crabbe 4, which has been

immune to cane canker appear highly resistant or immune to cane canker. At Beltsville, seedlings of Ashworth x 11-93 that were catalogued in the greenhouse for resistance to mildew have shown similar resistance in the field, thus screening for resistance to mildew in the greenhouse appears feasible.

Blueray, Bluecrop, Berkeley, and Coville, in solid stands have varied greatly in production in the field. When these varieties were tested for self-incompatibility under controlled pollination experiments in the greenhouse, Blueray set very few fruits but Berkeley, Bluecrop, and Coville set many berries. However, Bluecrop and Coville both set larger numbers of early-maturing fruit from cross-pollination than from selfing.

Grape breeding. At Fresno, Calif., none of the seedless vinifera selections appear superior to present commercial varieties. However, 1 red-fruited seeded selection, No. 10-79, that ripens a week earlier than Cardinal appears outstanding and is being propagated for extensive testing. Several late-ripening seedlings, both black and white, seeded types appeared promising. Approximately 2,300 new grape seedlings were added to the seedling test block, the results of 1959 pollination. Two selections from the breeding progenies for rootstocks resistant to nematodes and phylloxera (16-131 and 16-154) appears promising as understocks for Thompson Seedless showing a higher degree of resistance to root knot than 1613. These are under test in a commercial vineyard in which nematodes are a major problem.

In North Carolina, 152 muscadine selections are being studied for use as varieties or for parents in further breeding. Breeding has combined high flavor, high sugar, large size, and cluster type with self-fertility, vigor, productivity, and resistance to black rot. Six new tetraploid selections from crosses between 4x parents appear promising because of their large fruit size. Some of the 180 new bunch grape x muscadine colchipsoid seedlings appear very vigorous the first year in the field and seem resistant to foliage diseases. Five hexaploid seedlings obtained by treating triploids with colchicine appear very weak.

Self-fertile muscadine seedlings selected at Meridian, Miss., are under test at a number of locations and 42 other selections are under second test at Meridian. All of these combine self-fertility with high flavor, high soluble solids, and productivity. Some have shown tolerance to the omnipresent Pierce's disease virus. Two generations of inbred selections have been obtained for studying possible heterosis and inheritance in muscadine grapes.

In the bunch-grape breeding, 12 selections have produced 15 pounds, or more, of fruit per vine and have remained vigorous over the past 5 years, indicating tolerance to Pierce's disease virus.

At Beltsville, 560 young bunch grape seedlings were saved from a progeny of 930 which was screened for resistance in the greenhouse. Two selections on advance test have excellent fruit character and will be worth introducing if the vines continue to be tolerant to disease. US-519-28 x Romulus has produced many promising seedlings, some of which have seedless fruit with high soluble solids. One in particular produces seedless black-fruit of much promise. Additional information on inheritance of an albino fruit character indicates that it is recessive, with more than 1 gene involved, and that US-4617-41 and Concord differ in the number of genes for the character. Among 53 F₂ tetraploid seedlings of V. vinifera x muscadine considerable genetic segregation, especially in fruit characters, occurred. The incorporation of the disease freedom of muscadines into seedlings appears to be a good means for obtaining disease resistance.

Blackberry breeding. In North Carolina, two selections - a thorny and a thornless type, both trailing blackberries, which have large high flavored fruit and are disease resistant, continue to look good.

On the Pacific Coast 7 of the selections made in 1959 (US-Oregon 1120, 1122, 1124, 966, 977, 1050 and 1063) continue to look good, the first 3 of which are under consideration for introduction. Ten new thornless selections were made in 1960, one of which has fine quality, large sized fruit and is very productive. This is the first time that thornlessness has been combined with productiveness and good fruit characters. Most of the thornless progenies are not fruitful.

At Beltsville, 8 new selections of thornless, winter-hardy, blackberries were obtained following such a severe test winter that only 1 of 3 previous selections proved hardy. All 50 seedlings obtained from a cross of Burbank Thornless x Early Harvest are thorny, therefore, the thornless character is recessive. Colchicine treatment of a thornless tetraploid selection has given branches with 8x chromosome number.

At Carbondale, Illinois, 5,000 blackberry hybrid seedlings were grown, screened for thornlessness, and 50 thornless plants set in the field.

Raspberry breeding. In North Carolina, 2 black raspberry selections and 6 red raspberry selections are being tested for adaptation in southeastern United States. These combine high vigor, productivity, disease resistance, and acceptable quality as derived from Asiatic x American species hybridization with backcrossing to American-type raspberries. One of the black raspberry selections (NC-307) appears highly resistant to anthracnose and has been used extensively as a parent for further breeding.

At Carbondale, 1,200 raspberry seedlings set in the field in 1960 should fruit in the spring of 1961.

In Oregon, 5 red raspberry selections tolerant of heavy, wet soils (root-rot resistant) have been outstanding in size, intense flavor, color and appearance of fruit in both frozen pack and canned samples. These are US-Oreg-1022, 1088, 1094, 1095, and 1112. They are being tested extensively in the Pacific Northwest, and consideration is being given to introduction of 1022. Twenty new selections were made in 1960 on the basis of large size and attractive fruit. One thousand nine hundred and fifty new hybrid seedlings have been planted in a heavy soil where previous raspberries died in 1960, to screen for tolerance to root rot.

Strawberry breeding. In Oregon, 10 of the strawberry selections in advanced selection tests appeared outstanding in frozen pack tests and all are tolerant of viruses and resistant to red stele root rot. Two selections (2416 and 2433) are being extensively propagated for further tests and possible introduction. Eighty four new selections were made from the 5,000 seedlings that fruited in 1960. Many of the Fragaria chiloensis clones that were collected along the Pacific Ocean proved resistant to red stele and these are being used as new sources of resistance for the breeding work.

At Willard, N. C., 55 advanced selections appear promising out of more than 200 on test. Twelve are sufficiently outstanding to consider naming, since they are more productive than Albritton in replicated tests and are resistant to leaf spot and leaf scorch. In a comparison of seedling progenies of 7 crosses, the seedlings of Headliner x Albritton were so superior to all others in size of fruit, production, and attractiveness that 11 of 34 new selections were of this cross.

In Maryland, the cross of NC-1768 x Surecrop yielded 21 out of 75 new selections made, as being outstanding in size of fruit, firmness, appearance, and productivity as well as resistance to red stele. One hundred and seventy selections are being evaluated for horticultural characters in combination with resistance to red stele. Further screening of F_1 hybrids between cultivated varieties and F. chiloensis showed that 2 selections were immune to all the races of red stele and were moderately fertile. Two thousand seven hundred seedlings with these selections as parents are now being screened for resistance to red stele. In a study of the inheritance of resistance to race A-3, Yaquina (a selection of F. chiloensis from the Oregon coast) transmitted highest resistance to seedlings and the resistance was partially dominant. The next most resistant parent was N-3953, a selection of F. virginiana from North Dakota. Only 30 percent as many seedlings were obtained where Surecrop was used as a resistant parent as compared with Yaquina. When a combination of races A-1, A-3, A-4, and A-5 was used for screening seedlings progenies, Yaquina was the only parent that transmitted resistance to the seedlings in sufficient amount to yield resistant plants. Two-thirds of the seedlings with Yaquina as a parent were saved as resistant, whereas none were saved where Surecrop, del Norte, or N-3953 were used as parents.

Successful propagation was obtained under intermittent mist when red stele resistant seedlings were removed from contaminated soil, washed, and all roots cut off at the crown. Tests are underway to determine whether plants were freed of red stele by this method.

Midway, a new late-midseason, very productive variety resistant to the common race of red stele, has been introduced as a replacement for Temple.

In the new work at Carbondale, 78 selections were made from seedlings planted in 1959. Yield data and observations on a replicated planting of selections and varieties indicated 3 selections to be promising (Md-US-2593, 2601, and 2700). Yield data on a strawberry plot size study were obtained and the data is in the process of being analyzed to determine the proper size of plots to use for further investigations. At Cheyenne, 24 winter-hardy selections are being propagated for testing by cooperators in the Northern Great Plains and Rocky Mountain Region.

Plans: Blueberry breeding work will be aimed at increased earliness, more winter hardiness in Maine and Michigan, and disease resistance in New Jersey. Breeding for cane canker resistance in North Carolina will be expanded. Selections suitable to mechanical harvesting will be explored. Species hybridization with subsequent doubling of chromosomes by colchicine will be investigated.

Strawberry breeding will emphasize resistance to Race A-3 of red stele and to the use of F. virginiana and F. chiloensis as sources of resistance to the new races of red stele (A-5 and A-6). Resistance to foliage diseases will be a major part of the work at Carbondale and North Carolina.

Blackberry and raspberry work will continue to involve thornlessness and resistance to the raspberry root rot on the Pacific Coast. Raspberry and blackberry breeding at Carbondale will be expanded.

Major emphasis in grape breeding will be on seedless vinifera types, black-rot resistant eastern bunch types, and muscadine bunch grape species hybridization.

Publications: New small fruit research station. Blake, R. C. Fr. Vars. & Hort. Digest 14(3): 42. March 1960.

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Breeding blueberries for the Florida climate. Sharpe, R. H., and G. M. Darrow. Fla. State Hort. Soc. Vol. 72. 1959.

The nature of plant spots. Dermen, H. Nat'l. Hort. Mag. 39: 123-173. July 1960.

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Inheritance of resistance to the common race of red stele rot of strawberry. Stembridge, G., and D. H. Scott. Plant Dis. Repr. 43(10): 1091-1094. October 15, 1959.

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5. TREE NUT BREEDING AND VARIETY EVALUATION

CR

Problem: Develop new and improved varieties of tree nuts that are resistant to diseases, nematodes, and are more frost hardy; have better eating, nutritive and market quality and are better suited to specific uses than varieties now available.

Program: A continuing long-term program involving basic genetic studies as well as application of known breeding principals in development of new varieties carried on at Beltsville, Maryland; Federal stations at Fresno, California; Corvallis, Oregon; and Brownwood, Texas; informal cooperation with state experiment stations in California and Oregon and industry, and involving about 3 professional Federal man-years annually.

Progress: Almond. For many years the almond industry of California has needed varieties that would produce flat, small Nonpareil (standard variety) shaped kernels. Nonpareil makes up the bulk of the acreage with other varieties planted primarily as pollenizers. Eleven selections acceptable to the almond industry have been made, which are substitutes for or pollinators for Nonpareil. These are being studied for production, tree character, disease and mite resistance, and for nut quality.

Efforts have been made to produce or find a Nonpareil-type almond which blooms a few days later than Nonpareil; often only a few days will mean escaping frost. Several late flowering bud sports have been found on Nonpareil and have been propagated for evaluation.

When two separate late-flowering sports of the Nonpareil variety were grafted to the same tree they showed different bark coloration, growth habit and two to three days difference in time of flowering.

Almond breeding has been limited to interspecific crosses during the last 2 years. No more almond x almond crosses will be made until the present crosses are evaluated because of limited space for growing progenies. Selections of the present progenies are being made for determining resistance to mites, brown rot, leaf blight and hull rot. Prunus persica x almond, Prunus davidiana x almond and P. mira x almond, all backcrossed to almond feature very heavily in this year's work.

Apricot-almond hybrids were found to be female sterile. The apricot-almond hybrid has been propagated on apricot rootstock and is being treated with colchicine in an attempt to induce polyploidy, but so far has been unsuccessful.

Rootstocks adapted to low precipitation and drought conditions are being sought through hybrids of almond x P. andersoni and P. fremontii. These species are native to California and seem to possess the additional features of adaptation to limestone soils and resistance to soil organisms.

Persian walnut varieties and rootstocks: In cooperation with the Oregon Agricultural Experiment Station selections and varieties established in the test orchard were evaluated. The Nugget variety was eliminated because of early blooming; it was completely defoliated by a freeze on April 6, 1959. Certain other varieties were also found to start growth too early in the spring. Spurgeon and Adams were found to be the latest in starting spring growth. Two hundred and six (206) selected seedlings were evaluated on nut characteristics and 10 were selected for further evaluation. Howe, a new variety, reported to be blight resistant, was added to those in the test orchards.

In Oregon, nurserymen are using only Manregian and Carpathian seedlings for rootstocks for Persian walnut varieties. The demand for F_1 seed of Manregian far exceeds the amount available. Rootstock tests underway have not advanced sufficiently for conclusions.

At Beltsville, Md., tests were continued to find outstanding seed trees of Persian and eastern black walnuts for the production of uniform, vigorous-growing seedlings. Seed from 17 varieties and from selected seedlings of Persian walnut were planted and grown. None showed good germination or a satisfactory survival of seedlings through the winter. In a similar test of 12 varieties of eastern black walnut the variety Ohio gave highest germination and the most uniform seedlings.

Black Walnut. At Beltsville, Md., the evaluation of second generation seedlings from F_1 interspecific hybrids failed to indicate any outstanding individuals among trees fruiting for the first time. Some F_1 hybrids, grafted on older trees to hasten fruiting, fruited for the first time at 15 or more years of age and the seeds were planted to continue the breeding program.

In a test with 18 varieties of Carpathian or other origins, certain ones are very promising as regards yield of nuts, tree growth and hardiness. Of these the varieties Hanse~~x~~ McDermid, and Burtner are outstanding. Walnut husk maggot (fly) continued to be a serious problem in nut production and variety evaluation.

Filbert. Crosses were made at Beltsville, Md., between varieties and seedlings showing both high and low production of blank nuts in an effort to determine whether the pollen parent contributes to this condition. The set of nuts was very variable, in some cases very low and in others abnormally high, without correlation with blank nuts. Nine new selected seedlings are being propagated for testing as possible new varieties.

In Oregon, a comparative study of kernel and degree of filling was made of the nuts of 31 selections and varieties with Barcelona in percentage. In cooperation with the Oregon Agricultural Experiment Station an orchard of 25 of these selections is being established near Wilsonville,

Chestnut. At Beltsville, Md., one Chinese chestnut has been tentatively selected for introduction as a new variety. This variety bears heavily, the nuts are large in size, dark mahogany in color, and have excellent keeping quality.

Six other selections are being evaluated at Beltsville, Md. Three of these are F_2 seedlings from a commercial orchard on Eastern Shore of Maryland and the other 3 selections are from plantings at Beltsville. These selections and 3 varieties Nanking, Kuling and Meiling, will be topworked on 10-year-old seedling trees in replicated plots.

Seedlings originating from orange colored kernel nuts backcrossed to the parent gave 60 percent transmission of the orange kernel character at Beltsville. Further backcrosses are planned with the objective of developing the orange kernel character because of its higher vitamin content.

At Beltsville, chestnut trees irradiated with dosages of 10,000 r (roentgens) and above were killed. Below 10,000 r resulted in malformed leaves and shoots. Time is required before definite effects of the irradiation on mutations can be determined.

Fifteen months after inoculation with the chestnut blight fungus, 93 percent of Castanea dentata trees were infected, whereas only 29 percent Chinese chestnut, C. mollissima, were infected. C. sativa and C. henryi were intermediate in infection with 69 and 64 percent, respectively. F_1 hybrids between the American and Chinese species showed 85 percent infection. Backcrosses of these hybrids to the Chinese parent showed 68 percent infection.

Pecan. Because of an unfavorable season and lack of flowers at Brownwood, Tex., no crosses were made in 1959. However, some 2,000 seed nuts from crosses made in 1958 were planted in the winter of 1959-60.

Because of a very short pecan crop in 1959 few hybrid seedlings fruited. Of those fruiting for the first time several exhibited merits such as to justify propagation for further trial on the station. A selection from the cross, Mahan x Odom, which produces a large blocky nut of excellent characteristics, was considered very promising. Considerable scion wood from previous best selections was distributed to growers and cooperators under agreement for their trial in their orchards.

Twenty of the most promising selections made at Brownwood, Tex., are being propagated on bearing trees at Meridian, Miss., and eight at Shreveport, La. Only a few nuts were produced by certain of the new selections under test so that preliminary evaluations could not be made.

Plans: The tree nut breeding is to be continued on the present basis.

Publications: New variety (cultivar) names of nut trees should be registered. Crane, H. L. Proc. Northern Nut Growers Assn. 50: 10-15. 1959.

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Results of crack tests on nuts of walnut varieties and selections.
Painter, J. H. Ann. Proc. Nut Growers Society Oregon and Washington,
45: 13-15. 1959.

B. Physiology and Nutrition

6. APPLE AND PEAR PHYSIOLOGY AND NUTRITION

CR

Problem: Develop basic information on physiology of apple and pear trees as applies to use of chemicals for fruit thinning, fruit bud initiation, and fruit setting, nutritional requirements for tree and fruit growth which give maximum yield, quality and consistent annual bearing.

Program: Both basic and applied research is underway to develop information which is useful in developing procedures that will give maximum yield and quality and consistent annual bearing. The work is located at Wenatchee, Washington in cooperation with the Washington Agricultural Experiment Station and at Beltsville, Maryland and involves between two and three professional man-years annually.

Progress: Thinning agents. Proper thinning is an exceedingly important part of apple growing. An overloaded tree produces poor size, poor quality fruit, results in tree breakage, failure to initiate new fruit buds hence biennial bearing and creates nutritional problems, pest control and other problems apart from good growing. Hand thinning has become both impractical and too expensive. Dependable chemical thinning is almost a must to the apple grower. For this reason, considerable effort has been expended in this field. A new material (1-naphthyl n-methyl carbamate) sold under the trade name of Sevin as an insecticide has shown excellent qualities as an apple fruit thinner. Since environment in orchards vary from year to year and cannot be controlled, it is necessary to repeat treatments for several years in several locations in order to determine the response under varied environment. Extensive thinning experiments were set up in central Washington and alternately in Australia. The work in Australia coming in between growing seasons in this country provided for a gain of a year in results. A summary of results with 1-naphthyl N methyl carbamate (NMC) indicated that this material is a positive and consistent thinner on all varieties of apples tested. In the Australian experiments thinning was obtained over a wide range in timing. Of 61 treatments (1.5 lb. per 100 gal. on Jonathan, Delicious and Granny Smith), all resulted in some degree of fruit set reduction. About the same degree of thinning was obtained at 15, 20, and 25 days from full bloom. A 30-day treatment failed to thin significantly in 2/3 of the cases indicating the effectiveness of the material for thinning is sharply reduced after 25 days from full bloom. A wide range of concentrations were effective. No significant difference was obtained in the amount of thinning where the concentration varied from 1 to 3 lbs. of 50% wettable NMC per 100 gallons.

NMC resulted in a very high percentage of seedless fruits with Delicious but had no effect on the seed content of Golden Delicious, Winesap and Jonathan. Over-thinning with NMC was obtained on low and inside limbs of Delicious in 1/2 of the experiments.

Effect of fruit setting and thinning agents on pears. No good thinning agent has been found for pears. Failure of pears to set on check trees prevented evaluation of NMC on this fruit.

Pears with inadequate cross-pollination usually set less than a commercial crop. In Washington, where sprays of 2,4,5TP were applied to Anjou pears at 7-1/2 ppm after harvest in 1959 in 6 different orchards, no effect was expressed on the 1960 crop. Similar treatments on Bartlett were inconclusive because of frost.

Studies on flower bud formation in apple. At Beltsville, studies have been continued to gain information on the secret of flower bud formation. It has been shown that various factors including photoperiod and plant regulators can influence tree growth and flower bud formation of apples. Experimental work has been set up involving combinations of these factors in which 192 Jonathan trees treated with NAA and TIBA in series were given supplemental light exposure at 8 levels. There has been considerable tree response but results will have to await blossom counts in 1961.

Effect of nitrogen on growth, yield and quality of apples and pears. At Wenatchee, Washington, data was taken on plots with varying levels of nitrogen on Delicious and Golden Delicious apples now in their 13th year. These plots involve 150 different orchards in central Washington. Within the range tested, the higher the nitrogen level the greater the yield of fruit and size of Anjou pears. The effect on pears was much more striking than on apples. On apples with foliar sprays, the later the sprays were applied in the growing season the less effect they had on inhibiting color. Spray applications of urea as early as mid-July resulted in only 50 percent as good color as did trees adequately fertilized the previous spring with soil applications.

Russetting and foliage injury of apples by pesticide sprays. At Wenatchee, Wash., studies on russetting of Golden Delicious apples by insecticides was continued. When parathion was used in the first cover spray at insecticidal strength, 55 percent of the fruit showed russetting. When Flyac (2 quarts per 100 gallons of spray) was added, russetting was reduced to 20 percent. Guthion, Kelthane and Sevin caused 13.0 and 0 percent respectively. Experimental trees are being grown in mobile containers for study under different degrees of temperature and humidity.

Plans. Work will continue on various phases of physiological and nutritional factors which affect growth and reproduction of pears and

apples, with special attention to those which affect setting, growth and quality of the fruit.

Publications

1-naphthyl N-methylcarbamate, a new chemical for thinning apples. L. P. Batjer, and M. N. Westwood. Proceedings Amer. Soc. Hort. Sci. 75:1-4. June 1960.

Nutrition of fruit trees in the Pacific Northwest. C. G. Woodbridge, N. R. Benson and L. P. Batjer. Proc. Int. Congress Plant Nutrition. August 1959.

7. PEACH AND OTHER STONE FRUIT PHYSIOLOGY

CR

Problem: The nutrition of stone fruits is fairly well known but thinning, fruit set, fruit sizing and other physiological aspects continue to be problems.

Program: Research on specific problems is being carried on at Prosser, and Wenatchee, Washington in cooperation with the Washington Agricultural Experiment Station; Fort Valley, Georgia; Fresno, California; and at Plant Industry Station, Beltsville, Maryland. Approximately 1 professional Federal man-year annually is involved in the work.

Progress: At Fresno, Red Globe peach branches maintained at temperatures above 45° F. during the winter again had increased bud drop over unheated or untreated branches. Orchard bud drop counts have been made annually for 5 years on 13 peach, nectarine and one apricot variety, and will be related to detailed weather conditions recorded during these specific years.

Among several chemicals used for spray thinning of peaches at Beltsville, none proved satisfactory in 1960. Gibberellic acid proved to be helpful in obtaining early germination of Lambert sweet cherry seed which had been given partial after-ripening treatments. Further gibberellic acid treatment was necessary, however, after germination to maintain continued seedling growth. Peach trees planted in soil previously used for peaches grew more when given a fumigation treatment, than untreated trees at a test in Fort Valley, Ga.

Plans: These phases of stone fruit physiology and nutrition research are to be continued on the same limited scale.

8. NUTRITION OF TREE NUTS

CR

Problem: Nut trees tend to produce crops biennially. The physiological and nutritional conditions need to be determined that result in

optimum tree growth, crop production and quality of the nuts produced. Methods and practices should be developed whereby the optimum nutritional level can be maintained from year to year and yield the highest profits to the grower.

Program: A continuing long-term program involving basic physiological studies on tree growth, yield of nuts, and quality of the nuts produced in relation to the mineral composition of the leaves is carried on at Beltsville, Maryland; Federal stations at Albany, Georgia; Shreveport, Louisiana; Meridian, Mississippi; and Corvallis, Oregon, and industry and involving about 3 professional Federal man-years annually.

Progress: Filbert Fertilization: In the second year of a factorial fertilizer experiment, in cooperation with the Oregon Agricultural Experiment Station, involving 3 levels each of potassium (K) and the intermediate level of boron (B) the yield of nuts was increased by the K applications but not by the boron. The size, shell weight, kernel weight and average weight of the nuts was increased by K applications; B was without significant effect on the nuts. Applications of K significantly reduced the percentage of blank nuts in the crop. The application of K and B increased both the K and B content of the leaves. In addition the application of K increased the manganese content of the leaves by highly significant amounts although the K had no effect on the pH of the soil. Similar responses were obtained in another long experiment and involving 3 widely different soil types.

Blank nuts: In Oregon, nuts removed in August from trees in 19 orchards showed that on the average 14.4 percent of the nuts were blank or contained no kernel. The range was from 3 to 35 percent. Orchards that were highest in percentage of blank nuts in previous years were also highest this year. At Beltsville, Md., the range in blank nuts varied from 4.3 to 18.6 percent between selections or varieties in a mixed orchard at harvest. A male-sterile seedling discovered in 1958 produced 94 percent blank nuts in 1959. This may indicate both male and female sterility factors are associated with the blank nut problem. In studies at Beltsville, Md., of mature pollen of varieties from Oregon and Maryland showed extreme variability in empty pollen grains, the variety Barcelons in Oregon showing 40 percent empty pollen grains as compared with the variety Reed at Beltsville with less than 1 percent. All other studies made on this problem in Oregon and Maryland were without result.

Pecan. Mineral nutrition: At Albany, Georgia, nitrogen applied directly to the trees during the winter months significantly increased the yields over no treatment in 1958, but was ineffective in setting a crop in 1959. Samples taken in 1958 showed that the nitrogen applications significantly increased the nitrogen and manganese content in leaves, and significantly decreased the phosphorous and potassium content as compared to leaves from no treatment. The

higher levels of nitrogen and manganese was associated with lower quality of the nuts, as measured by the percentage of kernels in the nuts and the oil content of the kernels.

At Fort Valley, Georgia, applications of lime and zinc to mature pecan trees made 4 years ago have not influenced yields significantly, although in the 3rd and 4th year after treatment, the phosphorus content of the leaves was significantly decreased by the lime, and the zinc content significantly increased by the zinc sulfate.

At Meridian, Miss., soil tests in a pecan orchard showed residual calcium and potassium in Ruston fine sandy loam and loamy sand soils 4 years after discontinuance of 8 annual applications of 72 pounds of hydrated lime and 12.4 pounds of 50% muriate of potash per tree to separate plots. The residual effects, particularly of calcium, resulted in higher calcium in the pecan leaves. The percentage of calcium was highest and that of potassium lowest in the leaves of Moore and Schley trees in calcium-magnesium plots.

In Louisiana, in 1959 two factorial fertilizer experiments with Stuart trees in an orchard at Shreveport, in which N, P, and K fertilizers were used in one and N, Ca, and Mg, fertilizers in the other, nitrogen applications increased trunk growth in one experiment but not in the other. In each experiment and in two similar experiments in 1958 in north Louisiana, nitrogen applications increased the nitrogen content of the leaves and reduced the phosphorus content. No crop of nuts was produced in 1959, probably due to overproduction in 1958. Nitrogen fertilizers applied to Schley and Stuart trees at the rates of 3, 6, or 8 pounds N per square foot of trunk cross-section did not cause any significant differences in trunk growth in 1959. The application of 6 pounds of N per square foot trunk cross-section has increased production of these same trees in crop years. Therefore, this indicates that nitrogen may increase shoot growth more than trunk growth, thus producing more fruiting shoots. The application of 6 or 8 pounds of N per square foot of trunk cross-section increased the N content of leaves and in the Stuart leaves all rates of N applications reduced the P content significantly in 1958, but not in Schley leaves.

In a factorial fertilizer experiment in southwest Arkansas using Zn, P, and K soil applications there have been significant increases in the Zn and P content of the leaves of trees from applications of ZnSO_4 or superphosphate for several consecutive years, but the increased Zn or P has had no appreciable effect on the performance of the trees.

In a nitrogen-potassium fertilizer experiment on large Success pecan trees on heavy soil at Sherard near Clarksdale, Miss., in cooperation with the Mississippi Agricultural Experiment Station, 210 pounds per acre of ammonium nitrate applied under the branch spread of the trees in addition to the growers' blanket application of 150 pounds of ammonium nitrate per acre did not noticeably affect

tree growth. It produced slight, but significant increase in yield, size, and weight of the nuts, specific gravity and percentage of kernel. No consistent differences were produced by application of 200 pounds or 600 pounds, respectively, per acre of 60 percent muriate of potash under the branch spread of the trees.

Abnormal growth of Moneymaker trees: These abnormal trees in the Fort Valley, Georgia, area were observed throughout the season of 1959. Trees previously treated with high-calcium lime, and those more recently treated with dolomitic limestone, made growth approaching normal during the season. Deficiency symptoms observed in previous years did not develop on these trees or those not treated. The data on the chemical composition of the leaves showed that the zinc content of the leaves was lower and the magnesium content higher than when the deficiency symptoms appeared. These data indicate a better balanced nutritional condition for 1959 than for previous years. It remains to be seen if this will result in normal development of growth in 1960. Trees apparently affected with this same disorder were found in 3 new locations in 1959.

Thinning of pecan crop by chemicals: Because of the general light crop or no crop of nuts set on trees available for these studies, no additional work on this project was done in 1959. Yield of nuts by trees on which the crop had been chemically thinned in previous years was not significantly affected by the treatment.

Plans. No major changes in the work under way are planned. Emphasis is to be placed in analyzing accumulated data and preparing reports for publication on completed experiments.

Publications: The effectiveness of spray applications of zinc chelate, zinc sulfate, and the zinc sulfate with bordeaux mixture in the control of pecan rosette. A. O. Alban. Proc. Texas Pecan Growers Assn. 38: 56-59. 1959.

Why some pecan orchard soils may need lime. J. H. Hunter. Proc. Southeastern Pecan Growers Assn. 52: 49-57. 1959.

Fertilizing pecan orchards. J. H. Hunter. Proc. Southeastern Pecan Growers Assn. 53: 17-19. 1960.

Effect of aphid control on quality of filbert nuts. J. H. Painter. Ann. Proc. Nut Growers Society Oregon and Washington 45: 37-38. 1959.

C. Cultural Practices

9. APPLE AND PEAR CULTURE

CR

Problem: Develop improved production practices with particular

reference to pollination, planting distances and rootstocks which will result in reducing cost yet produce the maximum of high quality fruit. The present trend is to dwarfing stocks to get orchards into bearing earlier, and cut pesticide and harvesting costs. The best stocks, planting distances and length of life, etc., are unknown.

Program: This is a shifting program which prospers as time and materials permit but should be a full scale program. Small amounts of work are under way at Wenatchee, Washington in cooperation with the Washington Agricultural Experiment Station at the Federal station at Mandan, N.D. This program involves approximately 1 professional Federal man-year annually.

Progress: Pollination. In Washington, adverse weather often interferes with natural pollination especially when natural pollenizers are not present in sufficient numbers resulting in short crops or necessitating artificial pollination. Since bees are the most common natural carriers of apple pollen an experiment was set up to determine if hive inserts were an effective means for bees to obtain a pollen load. Pollen on hive inserts worked well on caged trees but failed in the open in commercial orchards. Failure in commercial orchards is thought to be due to insufficient visits by the bees or too light pollen load.

Tree spacing. In the Pacific Northwest, mature apple orchards should be spaced approximately 40'x40'. As young orchards, this spacing leaves much of the land unused. As a result of practice of 20x20 spacing with removal of alternate trees when the trees begin to crowd has been followed. The difficulty has arisen as to when the interplants should be removed.

In an orchard planted in 1947 (20x20) 24 plots have been mapped with the alternate trees to be removed in specific plots at 2-year intervals beginning in 1956. To date, 2 removals have been completed (1956 and 1958). Both reduced yields per acre and the remaining trees did not increase over the filler trees left in the other plots. Thus the first removals were removed before they needed to be.

Rootstocks. At Wenatchee, Wash., 10 replicated plantings of Golden Delicious, Delicious, and Winesap on a number of Malling dwarfing and standard stocks. were made in 1955. In 1960, Malling II and Malling VII had out-produced standard stocks. However, a number of the trees on the Malling stocks were weak and lacked vigor and indicated that if these stocks are used commercially they will require more exacting care than presently given to apples.

At Mandan, N.D., growers also want early fruiting dwarfed trees and in addition the rootstock has to be winter hardy and compatible with winter hardy varieties. A long term project is underway to

study the performance of apple varieties on hardy crabapple varieties. Some of these may turn out to be dwarfing stocks. Seedlings of a cross Dolgo X Melba have been selected because of their dwarfed habit and are being tried as rootstocks. Some of these seedlings have dark colored rough bark and thus may be resistant to sunscald.

Plans: Work will continue along present level.

Publications: Progress report on hive inserts for apple pollination. Carl Johansen and E. S. Degman. Proceedings Washington State Hort. Assoc. pp. 77-80. December 1957.

10. SMALL FRUIT AND GRAPE CULTURE

CR

Problem: To develop improved practices of propagation and culture, to determine field practices that will result in high production of good quality fruit and reduce production costs.

Program: A continuing program that is variable, depending on completion of certain phases of the work and initiation of new work. Federal locations are Fresno, Calif.; Meridian, Miss.; and Beltsville, Md. Cooperative work is in progress with Oregon and North Carolina stations. Work involves 1 professional man year annually.

Progress: Strawberry plant storage and culture. In cooperative work with Agricultural Marketing Service at Beltsville, cold-stored strawberry plants that were planted directly in the field on April 1, and May 1, produced too many runners and made too dense matted beds, whereas those set on June 1 were satisfactory for fruit production. The April 1 and May 1 plantings required too much labor to remove runners thus making the earlier plantings impractical. Plants dug from commercial nursery beds at Salisbury, Md., were no larger in mid-March than in mid-November of the previous years, which is contrary to a long-held belief of nurserymen.

Blackberry culture. Accumulative yields over a 6-year period of the Marion blackberry in Oregon indicates that plots receiving annual applications of nitrogen have given the highest yield and that a heavy initial application of phosphorus has been of no value.

Propagation of blackberries by hardwood cuttings has given poor rooting for most selections at Beltsville. A few selections have rooted up to 25 percent when 1- and 3-bud hardwood cuttings were used. The 1-bud cuttings made equally as good plants as 3-bud when lined in the nursery after they had rooted in the propagating beds. Treatment of hardwood cuttings with IBA was detrimental. Softwood cuttings taken July 1 gave a higher percent rooting under intermittent mist propagation than cuttings taken in August and September.

Selections differed in percent of plants obtained from softwood cuttings under mist propagation the same as with hardwood cuttings.

Grape culture. At Fresno, Calif., in studying the time of year during when bench-grafting of vinifera grape vines could be done, it was found successful at any time during the winter with proper handling of the grafts. When bench grafts were placed in polyethylene bags for holding during callousing, greater success was obtained when the bags were aerated. In closed bags CO₂ content was increased to 4.5 percent and oxygen was reduced to 8.4.

Plans: Storage of blueberry cuttings in relation to subsequent rooting will be investigated. Propagation experiments with blackberries will be continued and propagation of red raspberries by softwood cuttings will be explored. Work will be initiated to determine whether poor storage of Albritton and Pocahontas strawberry plants for extended period of time can be remedied. Grape propagation studies will continue at the same level.

Publications: The history of the development of the small fruit industry in Oregon. Geo. F. Waldo. Oregon State Hort. Soc. Ann. Rpt. 51: 79-83. 1960.

11. TREE NUT CROPS CULTURE

CR

Problem: Develop new and improved methods of culture which will result in maximum yields of high quality nuts and reduce cost of production.

Program: A continuing program involving soil and cover crop management and tree spacing. The work is carried on at Albany, Georgia; Meridian, Mississippi; Shreveport, Louisiana; Brownwood, Texas; Fresno, California; and in cooperation with the experiment station at Corvallis, Oregon, and involves about 3 professional Federal man-years.

Progress: Filbert Growth and nut production as affected by pruning: Experiments started in the winter of 1958-59 to study the effects of light and heavy pruning, as compared with none on mature filbert trees, have already shown promising results. New shoot growth of desirable and fruitful types has resulted from the pruning practiced. Although yields on pruned trees were expected to be less the first year than on unpruned trees, this was not always true; in some cases the lightly pruned trees produced the greatest weight of nuts. The loss in number of nuts due to pruning was offset by the production of larger and heavier nuts.

Effect of aphid control on yields: In cooperative work, with the Entomology Department of Oregon Agricultural Experiment Station, it was found that the control of aphids with demeton (Systox) resulted in an average increase in yield of 4.1 pounds per tree on the basis of 60 trees per plot. The nuts from the demeton treated trees were larger in size, weighed more but contained slightly less kernel than those from the check trees.

Pecans. Methods of establishing new orchards: At Shreveport, La., in 1959 only 60 percent of trees in orchards started in 1950 developed by planting seed nuts in place in the orchard and topworking the resulting seedlings to varieties were large enough to bear nuts, due to difficulties in getting a stand, whereas those developed from nursery trees were large enough to produce good crops. A tree developed from a seed nut dug in 1959 had a taproot 10.5 feet long whereas the one developed from a transplanted nursery tree had no taproot at all. To date the costs of establishing the nursery trees had been less, they have produced more nuts, and are larger. Further testing will reveal whether the taprooted trees will be better as they become older.

Irrigation and respacing of orchard trees: During a 7-year period at Brownwood, Texas, when average annual rainfall was 22.4 inches, soil moisture was the major factor in the performance of the trees. Irrigation increased the growth of the trees, nut production and the size and weight of the individual nuts, but the relative kernel development of the nuts was affected very little. Respacing the stand of the trees by removing half the number had the same effects in all respects as irrigation but to a smaller degree. Response of the trees was indicated to be due largely to the increase in the available soil-moisture supply resulting from the wider spacing. The yield of nuts of the trees of each variety under each treatment was generally in direct relation to the increase in cross sectional area of the trunks, thus indicating the importance of maintaining good tree growth. Thus under conditions of low soil-moisture best results are obtained if the roots of adjacent trees do not overlap. Although the remaining trees in a respaced orchard produced greater yields than those not respaced, the respaced orchard produced less nuts per acre. Where trees can be irrigated, trees can be grown under closer spacing. This experiment has been completed.

Orchard soil management: There were no consistent differences in tree growth in an experiment at Meridian, Miss., on Moneymaker and Success pecan trees from combining soil applications of nitrogen and potassium in varying ratios with summer sod or summer cultivation. Due to a total crop failure on both varieties in 1959, there are no results to report on yield, size, and quality of nuts produced.

In Fort Valley, Georgia, an area in an experiment where spring and summer clean cultivation is compared with mowing to keep grass and weeds under control, in 1959 yields of nuts in the 5th year from the initiation of the treatments were not significantly different between the 2 treatments. It would seem that growers might choose between the 2 types of summer culture on the basis of costs as the quality of the nuts produced, like the yields, have been about equal.

At Shreveport, La., a soil management experiment with bearing trees under way since 1951, in which a winter legume with summer cultivation

is compared with a winter legume and Dallis grass which is kept mowed, both with and without supplemental applications of nitrogen, showed in 1959 no significant difference in tree growth. There were no nuts produced probably because of the heavy crop in 1958. The chemical composition of the leaves sampled in mid-September 1958 was approximately the same for all treatments.

Persian Walnut Rootstocks. Nurserymen are now accepting seedlings of the Persian walnut race originally from the Carpathian Mountains and of the Manregian variety as rootstocks for the propagation of Persian walnut varieties. Two new sources of seed reported to produce cold hardy seedlings are under investigation.

Plans: No material change in these investigations is planned for the coming year.

Publications: Panel discussion on pecan fertilization, tree spacing, culture and management. A. C. Gossard Proc. Southeastern Pecan Growers Assn. 53: 12-13. 1960.

Comparison of transplanted nursery trees and seedlings budded in place for establishing a pecan orchard. O. W. Harris and C. L. Smith Proc. Texas Pecan Growers Assn. 38: 48-50. 1959.

Effects of irrigation and tree spacing (thinning) on pecan tree growth and nut production. L. D. Romberg, C. L. Smith and H. L. Crane. Proc. Texas Pecan Growers Assn. 38: 69-75. 1959.

Irrigation of pecan orchards. L. D. Romberg Proc. Southeastern Pecan Growers Assn. 53: 20-25. 1960.

Comparative effects of clean cultivation and sod on tree growth, yield, nut quality, and leaf composition of pecan. C. L. Smith, O. W. Harris, and H. E. Hammar Amer. Soc. Hort. Sci. 75: 313-321. 1960.

D. Weed Control

12. WEED CONTROL IN APPLES, CRANBERRIES, GRAPES AND STRAWBERRIES CR

Problem: New and improved chemical, cultural, biological and combination methods of weed control are critically needed to reduce root injury associated with mechanical methods, improve quality, reduce production costs, and facilitate mechanization of production.

Program: A continuing program of basic and applied research on the specific weed problems in these crops is conducted at Beltsville, Md.; New Brunswick, N.J.; and Prosser, Wash., involving approximately 1 professional man-year annually.

Progress: Control of weeds in young apple orchards. Grass and weeds around young trees hinder their growth and are expensive to remove with hand labor. At Wenatchee, Washington, a number of materials have been tried experimentally in a search to find one which is effective but which does not injure the trees or leave harmful residues. Several standard materials have been found effective in irrigated orchards but not in rill-irrigated orchards.

Chemical control of weeds in cranberries. At New Brunswick, N.J., preliminary results from greenhouse and bog tests indicate that several safe, effective new herbicides are tolerated by cranberries and research to determine their use in bogs over an extended period of time is underway.

Chemical control of weeds in grapes. Continuation of the studies with weeds in grapes in Washington showed promise for the practical use of late winter applications of diuron or simazine for control of many annual broadleaved weeds and weed grasses.

Strawberry chemical weed control. Investigations on the control of weeds in strawberries in Beltsville, Md., disclosed that neither yield nor quality of Pocahontas strawberries were adversely affected by a soil surface application of eptam following planting and again in late summer. Eptam when used at 10 pounds per acre as a spray on 12 varieties of strawberries immediately following planting stunted all plants severely. Three varieties (Blakemore, Tennessee Beauty and Earlidawn) were damaged more severely than any of the others.

Plans: New herbicides, new combinations and new methods of application will be evaluated to find more effective means of controlling weeds. The effect of continued use of herbicides on perennial crops will be studied under various soil culture and cultural and climatic conditions to determine the mode of entrance, the ultimate fate of the herbicide, and to determine the affect on yield, quality and longevity of the crop plants.

Publications: Response of strawberries to CIPC, Sesone, Simazin, Eptam and CPIC. L. L. Danielson and D. H. Scott. N.G.A. Abstracts. 1960.

An evaluation of several chemicals for their herbicidal properties, 1959 field results. W. A. Gentner, L. L. Danielson, and W. C. Shaw. USDA, ARS, CR2-60. 1960.

E. Disease and Nematode Control

13. APPLE AND PEAR DISEASE CONTROL

CR

Problem: Develop more factual information concerning fungus, bacterial, viruses and nematodes affecting apple and pear trees

which will enable development of economic methods of control.

Program: This is a continuing program which involves evaluation of newly developed fungicides for control of fungus diseases of apples and pears; development of improved methods for controlling bacterial disease, nematodes, and virus diseases affecting these fruits. Work is conducted at Beltsville, Md.; Clemson, S.C.; Hood River, Oreg.; Wenatchee, Wash.; and Riverside, Calif.; in cooperation with the South Carolina, Oregon, Washington and California experiment stations respectively. The work involves about 4 professional Federal man-years annually.

Progress: Fire blight. At Beltsville, Md., under epiphytotic disease conditions, Bartlett pears sprayed 4 times (2 bloom and 2 post-bloom) with 100 ppm of Agrimycin 100, showed considerably less fire blight than untreated or check trees. Based on blighted twigs, the checks showed an average of 135 blighted twigs per tree while those treated with antibiotic showed only six.

At Beltsville, leaves of fire blight resistant Magness (3866E) and blight susceptible Bartlett pear were found to contain a substance or substances which inhibit growth of fire blight bacteria Erwinia amylovora. It has been repeatedly demonstrated that resistant Magness variety contains significantly more of this substance than does susceptible Bartlett. Young leaves appear to contain more than old leaves and more is present early in the season than later. If techniques can be developed for testing of very young hybrid seedlings for blight resistance, there could be a highly significant saving in time, money and effort in the breeding program.

Apple scab and powdery mildew. Apple leaf scab field evaluation at Beltsville, comparing dilute (greater than 500 gallons per acre) water sprays of captan with concentrate (one to two gallons per acre) sprays of nonphytotoxic mineral oil, show significantly better disease control with the former. However, statistical analysis shows that when 1/4 pound of dodine is suspended in the oil, control is further increased. Further studies will be conducted.

Combined scab and mildew field spray studies on Rome apples under relatively light disease conditions show all chemical treatments evaluated gave significant control of leaf scab as compared to the check. Captan gave better control of leaf scab than all other treatments according to counts but was not statistically better at the 5% confidence level than Indopol polybutene compounds. The polybutenes were significantly better, however, against powdery mildew than captan alone but poorer than Karathane used in combination with captan.

In another powdery mildew study on Rome apples at Beltsville, wettable sulfur at 2 lbs. per 100 gallons of water again proved as effective as Karathan. Polybutene H 100 (1 gallon per 100 gallons water) was poorer than 1/2 pound but as good as 1/4 pound Karathane.

Because the polybutene emulsions tended to break down too soon it appears that reformulation may improve their effectiveness.

Laboratory and greenhouse evaluations are continually being made in an attempt to find new organic compounds for control of bacterial and fungal organisms causing fruit tree diseases.

Pear decline. Pear decline has developed into a catastrophic disorder which will seriously reduce the nation's supply of pears for a time and which will ruin many of the most productive pear orchards in the best pear districts. It was first seen in Washington in 1946 and by 1955 had reached serious proportions when major research began. It appeared in Oregon in 1957 and by 1960 whole orchards had died. In California, surveys in 1959 indicated over 10,000 trees killed; in 1960 this number jumped to over 100,000, an increase over 1000 percent. The Pacific Coast States produce 95 percent of the nation's quality pears with a farm gate value of over \$50,000,000. The disorder affects all varieties and kills trees which are growing on Oriental rootstock. Estimates vary on the amount of this rootstock used but most agree that it is 50 percent or more, when all pear districts are considered.

The cause of pear decline is still unknown. However, certain general summary conclusions can be made. Pear decline is a disorder new to the pear industry. The apparent rapid natural spread within orchards and area to area indicates a biological agent which can move on its own and which may incite the disorder itself or carry an inciting agent. Analogies have been drawn with known virus diseases such as X-disease of stone fruits which kills cherry trees if they are growing on mahaleb cherry rootstock whereas trees on mazzard rootstock become invaded by the virus and are not killed; also with tristeza of citrus which kills sweet oranges on sour orange rootstock but affects trees very little on sweet orange. Experimental transmission from diseased to previously healthy plants in some manner is considered necessary for establishment of virus as a causal agent. Research evidence has reached the point where it can be concluded that pear decline is not the result of unfavorable cultural conditions, improper irrigation, unfavorable soil, malnutrition, improper use of new pesticides or fertilizers or a simple bud union incompatibility.

The decline and death of trees is caused by death of the phloem (the food conducting tubes in the bark which transport food made in the leaves to the roots) of the rootstock just below the bud union, thus girdling the trees. The disease is almost exclusively restricted to trees on oriental rootstocks (*Pyrus serotina*, *P. ussuriensis* and *P. calleryana*). Fortunately, orchards on domestic Bartlett seedlings or on Old Home (a fire blight resistant body stock) which has scion rooted have not been affected. The Oriental rootstock was used between

1920-1940 because of blight resistance and good vigor but was abandoned when hard end, a disorder of the fruit, was associated with them.

At Wenatchee, Washington, major emphasis has been from the standpoint of determining the cause of the disorder. In experimental plantings on a number of rootstocks made in 1959, 35 percent of the trees on P. serotina and P. ussuriensis died suddenly in 1960. Similarly, 20 percent of new plantings made in the spring of 1960 are dead. Some trees had made 3 feet of growth before they suddenly died. These results indicate that the inciting agent is too prevalent out-of-doors for transmission studies. Studies already under way in a screened greenhouse involve nursery trees of Bartlett variety tops on P. ussuriensis rootstock. (Both the variety scions and the rootstock seedlings were obtained from sources outside the pear decline area). Inoculated and check series have been set up with inoculum coming from typically affected Bartlett and Anjou in commercial orchards.

A large collection of pear species and varieties has been assembled at Wenatchee and will be used in top-rootstock combinations to determine which varieties and combinations are affected.

In 1959, 45 trees growing on domestic Bartlett seedling roots which were showing suspicious decline symptoms were sampled and none showed the phloem necrosis below the bud union characteristic of pear decline. Orchard surveys showed trees growing on domestic Bartlett seedling roots (2-15 years old) were making normal growth. In many instances, these trees are replants in orchards where pear decline affected trees had been removed.

Individual tree ratings of 50 "record" orchards were made for the fifth consecutive year in the Yakima area. There was very little increase in decline, suggesting that the disorder had run its course. In other words, the most sensitive stocks may already have succumbed and those remaining may be resistant.

Apple viruses. Virus diseases continue to be an item of major interest to the apple industry even though none have assumed major importance. There are about a dozen viruses known to affect apples, several of which are in the United States. The most important ones at the moment are those which are generally latent and wide spread in the standard apple varieties and become expressed when these varieties are top worked onto sensitive rootstocks or stem pieces. With the current interest in dwarfing stocks and winter hardy body stocks, necessitating multiple trees, there is more opportunity to get sensitive combinations of virus bearing varieties together. There is urgent need for an expanded program in this field. To this end, a virus-multiple tree dwarfing stock workshop has been organized to be held in August 1961 at the University of Illinois to develop coordinated research plans.

Evidence continues to pile up indicating wide occurrence of latent viruses in standard varieties and propagating stocks. Malus platycarpa and several other index host plants are used as indicators. Evidence continues to increase indicating wide occurrence of the virus which causes stem pitting on Virginia crab.

At Wenatchee, Wash., work has shown russet ring, reported in 1959 is readily transmissible to a number of apple varieties with symptoms produced on some 9 months after inoculation. Foliage symptoms consist of leaf puckering and reduction in size and fruit symptoms consist of russeted surface often in the form of rings which sometimes are slightly depressed. Surveys in over 50 orchards in Chelan, Douglas and Okanogan Counties have shown over 2,000 affected trees. Fruit from these trees will be reduced in grade, thus causing serious economic losses.

A disorder similar to star crack (a virus disease) was found in an orchard near Wenatchee in 1959 and has been transmitted. Its significance is not yet known.

A new disorder similar to false sting was found in 1960. Tests to determine whether it is transmissible are under way.

Plans: The work on fire blight will be expanded in an effort to determine more about conditions favorable for its occurrence and to find chemical and biological means of control. The work on fungus diseases of apples will be continued with as much work as time and materials will permit. The work on pear decline will be expanded from the standpoint of determining etiology and determining sensitive combinations.

Publications: USDA Leaflet 187 (revised). Blight of pears, apples and quinces.

Russet ring, a graft transmissible disease on Golden Delicious apples. E. L. Reeves and P. W. Cheney. Proc. Wash. State Hort. Assoc. 55:157-158. 1959.

Some apple virus disease problems in Washington. E. L. Reeves and R. C. Lindner. Proc. Wash. State Hort. Assoc. 55:117-119. 1959.

14. PEACH AND OTHER STONE FRUIT DISEASE CONTROL

CR

Problem: Develop more factual information concerning the diseases affecting stone fruits which will make possible development of economic methods of control.

Program: Work on fungus and bacterial disease control is a continuing program of both basic and applied research and is conducted in cooperation with the South Carolina Agricultural Experiment Station

Clemson, South Carolina, and at Plant Industry Station, Beltsville, Maryland. Research on virus diseases is conducted at Fort Valley, Georgia; Riverside, California; Logan, Utah; Wenatchee, Washington; Madison and Sturgeon Bay, Wisconsin. Work in California, Utah, Washington and Wisconsin is in cooperation with the respective agricultural experiment stations. This work involves approximately 7 professional Federal man-years annually.

Progress: Crown gall. In South Carolina three chemicals selected from the laboratory screening program, when field tested, failed to show significant disease control. Vapam one of the materials tested did, however, significantly increase the size of the June-budded peach trees. Studies are currently under way testing the effects of various concentrations of oxytetracycline used as root dips at various time intervals after digging.

Clitocybe rootrot. Because Clitocybe tabescens is frequently associated with roots and trunks of dying or dead peach trees, a study has been underway at South Carolina for several years to determine the effect of the fungus on the roots of young trees planted in sterilized soil and trees under orchard conditions. Ten months continuous contact of pure cultures of the fungus with injured or uninjured roots of peach seedlings failed to produce any effect. In the orchard, localized infections occurred in 1 to 2 roots on 8 of 20 trees exposed to the fungus for 4 years in rotting peach wood, but there was no above-ground symptoms of infection.

The short life of peach trees in the southeast may be in part due to the prevalence of wood-rotting fungi. Thirty-five species of fungi were found associated with wood decay of living peach trees in South Carolina. Of this number 23 species apparently are unreported on peach in the United States. Nine species are considered as contributing materially to early decline of peach trees.

The sudden death or decline of many peach trees in South Carolina during the past season has caused great concern to both growers and scientists. A survey showed that 250,000 to 400,000 trees died or declined which is about 8% of the total planting for the state. Two different groups of symptoms appear to be associated with the condition, one is similar to those described for bacterial canker (Pseudomonas syringae) and the other similar to what is called "wet feet" or crown rot caused by Phytophthora spp. Isolations from various tissue of the trees and surrounding soil are being made in a search for possible pathogenic agents.

Virus diseases of peach. Phony. In Georgia analysis of data indicate that the incidence of phony in young orchards up to 4 years old is due to spread into the orchard from outside sources. Phony expression in trees after the 4th year, fits more into a spread pattern within the orchard.

Weeds as vector hosts. Peach growers who neglect weeds and who plant cover crops and intercrops in peach orchards tend to have more trouble with phony disease than do growers who practice clean culture. However, growers who permit orchards to become weedy usually clean up the orchards after peach harvest season and so force the vectors of phony to feed on the trees. In order to demonstrate that vectors breed on weeds, Johnson grass, and field peas and that these plants should not be tolerated in peach orchards, an elaborate experiment was laid out. The results of the experiment were exactly the reverse of those expected. After 4 years of growing weeds, Johnson grass, and field peas in peach plots, there was not one phony tree resulting from spread from the 96 phony trees set in the plots as inoculum. The vectors prefer weeds, Johnson grass, and peas as food plants. The vectors were observed feeding on these hosts but not on peach. It is suggested that these hosts acted as trap crops and protected the trees from infections. If this line of reasoning is correct, then growers should be urged to spray the orchard floor before destroying a weed cover or a cover crop.

Peach rosette. In Georgia, red maple has been demonstrated to be a host of peach rosette. Collections have been made from swamp trees for indexing where many trees show suspected symptoms. This is a new host for rosette and may help explain the virus reservoir from which sudden outbreaks occur.

Peach mosaic. At Riverside, California, the variety Curlew has been found a good reactor and index host for peach mosaic. Nursery trees inoculated in the fall will show symptoms before the end of the following growing season.

Plum hosts. Commercial plums often do not show symptoms when inoculated with peach mosaic virus. Since most plums are commercially propagated on known mosaic-susceptible hosts such as peach or myrobalan, it has been necessary to propagate them on their own roots before they could be tested. Of the 36 varieties so tested on 13 failed to show symptoms and 12 of these proved to be symptomless carriers.

Peach varietal expression. A continuing program of testing the reaction of new varieties is carried on. Tolerant varieties which are little damaged are desired in the heavily infected areas where no roguing is carried on, but should be outlawed from control areas because of the difficulty of diagnosis and hence missed infected trees become virus reservoirs.

X-disease. In Washington, X-disease continues as a threat to both peaches and cherries but does not cause as much economic loss as 10 years ago. This is probably due at least in part to incorporation of more effective insecticides in both the cherry spray program and in the forage and other vector breeding grounds crops. There are still many diseased chokeberries which stand as reservoirs should an opportune year for spread occur.

In Utah X-disease is still a serious disease, causing more losses on cherries than on peach. Diseased chokecherries abound in the hills and borders near orchards but surveys show that much of the loss in cherries is due to spread within the orchard. More promising control is being shown where sweet cherry varieties are used to topwork individual arms of the new cold hardy mohaleb scaffold trees. If such sweet cherries become infected the infected arm may die, may be removed or in some cases loses the virus and recovers. The Long Stem Bing variety has never been found naturally infected on such topworked trees and thus appears to be either tolerant or not acceptable to the vector.

Little cherry virus. Previously at Wenatchee, Wash., it was reported that all plants of Prunus serrulata, Oriental flowering cherry, Vars. Kwanzan and Shiro-fugen used as test plants to index for the presence of Prunus ring spot were infected and symptomless carriers of the little cherry virus and were probably the vehicle in which the virus entered America. These species are very valuable as test plants and are much needed but the wisdom of their use in areas where little cherry is not present in commercial orchards is doubted. A search has been made to find little cherry virus free sources, to make one or to find a substitute. To date one clone of Kwanzan (Sturtevant) from New York after extensive test appears to be virus free. A clone of Shiro-fugen heat treated by Dr. George Nyland of the California Experiment Station has tested free. A number of other flowering cherry varieties have been tested for ring spot and failed to react, therefore they are of no value as test plants for that virus. The variety Shiro-higan appears to react strongly to ring spot and is free of the little cherry virus but more work is needed to determine whether it will be specific for ring spot and will indicate all strains.

Other virus diseases. Necrotic rusty mottle. Necrotic rusty mottle continues to be a hazard to sweet cherries in the Northwest and in Utah. It is most serious on Lambert but the more virulent strains affect other varieties. The new Canadian variety, Sam, appears from tests at Wenatchee, to be more seriously affected and hence a better test plant for all strains than Lambert.

Apricot ring pox. Evidence continues to mount of widespread occurrence and natural spread of the ring pox virus in western United States. It affects a large number of varieties of apricot, principally the Tilton types, and spreads into such varieties as Royal when it exists without symptoms. New results in Utah have shown peach and sweet cherry to be native hosts and to harbor both the regular and pit pox types. These hosts were simultaneously infected with two other viruses, asteroid spot and mild rust mottle - a beastly mixture.

Apricot pucker leaf. A new virus, pucker leaf, was found affecting apricots in Washington County, Utah. It has been transmitted to peach where it produced leaf symptoms, but like on apricot, no fruit symptoms.

In Washington, new results indicate that Italian prune and the Pacific plum, P. subcordata, are immune to ring pox, as such they can be used for sieving hosts to eliminate ring pox from mixed virus cultures.

Prunus ring spot. Prunus ring spot remains a major problem in fruit trees, particularly stone fruits where it is of extremely wide occurrence, in which it is seed borne and in which it is latent after initial stages but in which it causes insidious symptoms of reduced vigor and complicates studies with all other viruses.

At Riverside, California, tests are under way with pure cultures to determine how much reduction is due to ring spot; all the work up to this point has been done with what is now presumed to have been mixed cultures.

In Wisconsin, ring spot has still not be disassociated from the sour cherry yellows disease, although it is found free of it in nature. Seeds from a Montmorency sour cherry tree known to be infected with sour cherry yellows, ring spot, recurrent ring spot and prune dwarf viruses were grown and the seedlings were of 3 classes: (1) contained ring spot virus without symptoms; (2) showed recurrent ring spot; and (3) showed no symptoms and indexed free of all ring spot.

Prune dwarf. The prune dwarf virus which is latent in all hosts except domestica plums and produces stunting on peach is of wide occurrence and thus was suspected of seed transmission. In Wisconsin, of 1,000 Italian prune seedlings grown from seed from prune dwarf affected parents, only 5 have shown symptoms.

Prune dwarf expression was found to be strikingly affected by temperature. Grown with a day temperature of 72°F. and night temperature of 55°F. expression was severe on Italian prune trees in the greenhouse. Under constant 72°F. temperature symptoms were entirely masked.

Sweet cherry mottle leaf. At Wenatchee, Washington, new results have shown apricot and Italian prune to be natural hosts of the cherry mottle leaf virus without symptoms.

Apricot gumvirosis. A new virus which ruins the apricot variety Wenatchee was described from the lower Yakima Valley, Washington, in 1958. At Wenatchee where a large variety collection

was available tests were set up to study variety reaction. Of the 50 varieties infected in 1959, 38 expressed symptoms, 11 of which died by September 1960. This promises to be a serious disease.

Plum rusty blotch. Plum rusty blotch was described as a new disease affecting the Santa Rosa variety in 1959. Further surveys have shown the virus to be of wide occurrence in California and was recorded on seven plum varieties in fifteen counties. An extensive study of the host range is under way.

Virus mixtures and separation. In Washington, studies have shown that certain prunus species may act as sieves which take out certain viruses from mixtures when inoculated with the mixture, e.g. (1) passage through apricot eliminated ring spot from a culture of twisted leaf virus; (2) ring spot was eliminated from necrotic rusty mottle when passed through P. serotina; and (3) little cherry virus was eliminated from cultures when passed through peach.

In Wisconsin, 4 viruses have been isolated from cherry and used to produce antisera. The antisera confirmed other tests that the viruses are unrelated.

In Washington, using purification, serological and transmission techniques, viruses in stone fruits, apples, pears, brambles, roses and weed hosts were found that were related to raspberry yellow dwarf and alfalfa mosaic viruses.

Chemotherapy. Studies of a fundamental nature have been continued in an effort to develop basic information on how viruses multiply in plants in the hope of finding a weak link where they can be inhibited chemically. Of the numerous chemicals so far tested 8-aza-quanine has the largest differential between virus inhibition and plant toxicity. It appears to protect plants from virus infection, a reaction which is carried through 3 seed generations with gradually diminishing effect.

Vectors. Cooperative routine assistance has been given entomologists in the way of furnishing plant materials, virus cultures and aid in identification. A result of this cooperative effort was the successful transmission of the mottle leaf virus from naturally infected bitter cherry, Prunus emarginata, to sweet cherry with an eriophyid mite.

Plans: No major changes are contemplated in this important field, except as new findings may indicate. The work on fungus and bacterial diseases will be expanded as time and facilities permit. The work on viruses continually fluctuates with one or another phase becoming more important.

Publications: Rio Oso Gem peach seedlings as indicator hosts for the Prunus ring spot virus Pine, T. S. and H. E. Williams. Plant Disease Reprtr. 44(5): 324-325. 1960.

Plum rusty blotch - a transmissible disorder found in southern California. Pine, T. S. and L. C. Cochran. Plant Disease Reprtr. 44(2): 87-88. 1960.

Serological differentiation of prune dwarf and sour cherry necrotic ring spot viruses. Fulton, R. W. and R. I. Hamilton. Phytopath. 50: 635-636. 1960.

Flowering cherry, a reservoir of the little cherry virus. Wilks, J. M. and E. L. Reeves. Phytopath. 50: 188-190. 1960.

Comparative inhibition of virus multiplication by certain types of chemicals. Lindner, R. C., H. C. Kirkpatrick, and T. E. Weeks. Phytopath. 49: 802-807. 1959.

The Airbrush as a tool in virus inoculations. Lindner, R. C. and H. C. Kirkpatrick. Phytopath. 49(8): 507-509. 1959.

15. SMALL FRUIT AND GRAPE DISEASE CONTROL

CR

Problem: Determine causal agents and develop effective and economical methods of control for important fungus, nematode and virus diseases of berry and grape crops.

Program: Continuing long-term experiments in field and laboratory are conducted at Beltsville, Md., and in New Jersey, California and Oregon in cooperation with the Agricultural Experiment Stations. Work involves 5 professional Federal man years annually.

Progress: Strawberry viruses. At Beltsville, refinements of indexing methods have revealed two viruses in some variety stocks previously released as virus-free. Plants have been heat treated in an attempt to rid them of latent A virus. Stocks of the varieties Sparkle, Dixieland, Albritton, Fulton, Fletcher, Frontenac, NY-547, and Cyclone, free of virus, have been propagated. A stock of Redcrop appears free of virus, following heat treatment. Indexing of virus-free stocks at the end of one season after it was grown by 19 cooperators in 15 states, revealed virus infection ranging from 0 to 66 percent. Mottle virus occurred in stocks from Indiana, Kansas, Massachusetts, Michigan, Ohio and Virginia. Latent C virus was found from Michigan only. Veinbanding was found from plants in Ohio and Pennsylvania. Twelve percent of the 191 indexed plants had become infected in one season.

At Corvallis, Ore., virus-free plants of Marshall and Northwest have been obtained from a combination treatment of heat and spraying foliage with beta-propiolactone. Many strawberry selections from the U.S.D.A. breeding work appear to be virus-tolerant when inoculated with a complex of Pacific Coast viruses. However when they are

inoculated with latent C in addition to other complexes, plants of all selections were severely stunted.

Strawberry nematodes. Samples from a one-third acre field of light, sandy soil purposely infested with root-knot nematodes show a high and fairly uniform nematode level. Nematocide treatments to determine relative effectiveness are planned for application in the spring. Preliminary results of an investigation with Nemagon show the nematocidal activity limited to areas with a few inches of the point of application.

Strawberry red stele. The cause of red stele disease of strawberry, Phytophthora sp. continues to give rise to new races. All U. S. and Canadian collections and some British collections have fitted into 6 U. S. races. Two British isolates do not fit the U. S. races but no isolates were pathogenic to all 5 U. S. differential strawberry hosts. The fungus has been cultured on a complex chemical medium consisting of 10 mineral elements, glucose and 5 amino acids in an attempt to develop a method of producing inoculum in quantity. The soil fungicides, Vapam and Trizone, have good field control of the fungus in fumigation trials but may not have eradicated it.

Rubus virus diseases. At Beltsville, stocks of the following 11 red raspberry varieties have been obtained which appear to be free of viruses: Canby, Cuthbert, Durham, Indian Summer, Lloyd George, Milton, Newburgh, Rideau, September, Taylor, Willamette. Indexing of 35 of the most vigorous Latham stocks that could be obtained showed all infected with raspberry mosaic. Heat treatment has not freed Latham of all viruses. Amphorophora rubi, aphid vector of raspberry mosaic has a restricted host range, feeding only on certain raspberry varieties, Loganberry, Wineberry, and on wild red raspberry. The wild Wineberry is an important reservoir for raspberry mosaic but wild black raspberry does not appear to be a reservoir. Black raspberries have remained mosaic-free for 2 years in commercial plantings in Maryland and Pennsylvania where low populations of A. rubi were present on other hosts.

Red and black raspberry curl viruses have been successfully transmitted by petiole grafting to red raspberries but only the black raspberry curl could be transmitted to black raspberry. Aphis rubicola, which occurs abundantly on raspberry, was found to transmit beta curl to black raspberry. Aphis rubifolii which occurs abundantly on blackberry, failed to transmit raspberry curl to raspberry. Mild streak was not transmitted mechanically nor by feeding with Amphorophora rubi. A new virus causing yellow-vein in raspberries has been graft-transmitted from symptomless Lawton blackberry to several Rubus species.

Blueberry diseases. In New Jersey, the response of 13 varieties of blueberries to 5 viruses has been studied; most have shown symptoms although a few appear to be either immune, symptomless carriers or require a long period for incubation and expression. Red ringspot spread at a rapid rate this past summer increasing from 14 percent to 24 percent infection in one field in New Jersey. Neither necrotic ringspot nor mosaic have shown any increase in the surveyed areas this year but several naturally infected specimens were observed in other states. Necrotic ringspot has now been observed from several locations in New Jersey, Connecticut, Illinois and Michigan. A mosaic-like condition in Coville is also widespread. Replanting of infected sites has not shown red ringspot or necrotic ringspot to be soil borne.

In attempts to find herbaceous host index plants for necrotic ringspot, 4 of the 20 tested developed good local lesions and may prove useful.

Isolations of the blueberry canecanker fungus were made from 6 different hosts to study the possible existence of races. There was no morphological distinction between these isolates; physiological studies are in progress.

Cranberry diseases. In New Jersey, ground spray applications of fungicides were more effective than aerial applications. Gravity or pressure feed systems in aerial application showed no essential differences in control. Aerial dusting gave control equal to that given by aerial spraying. The amount of cranberry fruit rots was not influenced by soil, foliar environment or internal berry temperatures, as indicated by studies made in bog sites exhibiting severe and mild rot. Preliminary measurements of relative humidity, however, indicated some contrast between the sites.

Grape viruses. A study of symptom expression of 6 grape viruses was made under greenhouse conditions. No symptoms of leaf roll nor asteroid mosaic are detectable but veinbanding and fanleaf symptoms show fairly plainly. Yellow-vein and yellow mosaic symptoms were obscure.

At Meridian, Miss., 4 varieties indexed for fanleaf virus have shown no symptoms after 6 months. Continued work with Pierce's disease has shown that the virus is probably universal in grapes, both native and cultivated varieties. Those that persist are either pure muscadines or hybrids having muscadine, champini, simpsonii or other native grapes in their parentage.

In California, 8 viruses are now known to affect grapes, two of which, vein-banding and rough bark, were discovered in 1959. Leafroll virus, which is one of the most common ones, spread naturally in the virus-free foundation plantings at Davis in 1959 with about 3

percent of the vines becoming infected. Baco 22A vines inoculated in 1959 with leafroll showed abrupt severe stunting of the plants which continued in 1960. Studies with K42 showed that the leafroll vines did not take up potassium nearly as well as the healthy vines. Contrary to previous reports the leaf petioles of leafroll vines were deficient in potassium as compared to healthy vines. Application of potassium sulfate during the winter to leafroll affected vines at the rate of 3,000 pounds per acre did not alter the expression of leafroll symptoms the following September. Leafroll symptoms developed equally as well at high and low levels of magnesium.

At Fresno, in a survey of a 20-year old commercial Emperor vineyard, more than 33 percent of the vines on 1613 rootstock had leafroll but own-rooted vines in an adjacent section had less than 1 percent indicating the 1613 as the source of the infection and little if any natural spread of the disease to the presumably healthy part on its own roots.

At Davis, Calif., in the greenhouse the fanleaf virus was transmitted mechanically in juice from grapes to Chenopodium amaranticolor and Gomphrena sp. several times. Transmission from Chenopodium or Gomphrena back to grapes was not accomplished but the virus was readily transmitted from Chenopodium to Chenopodium with symptoms being expressed in about 7 days from inoculation.

A study was undertaken to determine whether the Xiphinema index nematode which is a vector of fanleaf can be eradicated from old vineyards. In a vineyard where vines were pulled in September of 1957, treated with 400 pounds per acre of methyl bromide in September 1959, grape roots and nematodes were found alive at a depth of 4 feet in the soil in June 1960. On a similar site, where carbon bisulfide was used at the rate of 300 gallons per acre live nematodes were found at 2 feet in June. In a number of samples, live X. index were found at a depth of 8 feet in the soil regardless of surface treatment. In greenhouse tests where X. index were held in moist soil without grape roots the nematodes died after 8 months and none were recovered from these soils when small grape vines were planted in them. Work is underway to try to kill grape roots in the soil by treating the tops with herbicides before the vines are pulled. Tests with 2,4-D amine applied as sprays during midsummer show that vine tops can be killed outright with low concentrations of the material.

In the experimental rootstock plantings of grape vines at the Irrigation Experiment Station, Prosser, Washington, symptoms of fanleaf and other soilborne grape viruses were apparent in September 1960 on stocks obtained originally from the U.S.D.A. station at Fresno several years ago. No extensive distribution of rootstocks has been made from this planting since the Concord industry in Washington is not

on rootstocks. In the Yakima Valley there was little evidence that fanleaf was present in Concord plantings.

Vein banding, one of the newly discovered viruses, was found to be soil-borne by greenhouse pot experiments. The actual vector is not known. The fleck condition in St. George indicator vines is vein banding virus. Attempts to transfer vein banding by mechanical means to Chenopodium amaranticolor have not been successful but frequently fanleaf was transmitted from vines that were also carrying vein banding. Vein banding can be inactivated by holding affected vines at 100° F. for 4 weeks but not after 3 weeks.

The Xiphinema index nematode was established as a vector for the yellow mosaic virus.

Yellow vein virus was mechanically transmitted to Chenopodium amaranticolor. Symptoms appeared in about 11 days after inoculation, giving distinct local lesions followed by a systemic reaction that kills the growing point. When sensitive grape vines are used for indexing, a period of 2 to 3 years is necessary to determine whether yellow vein is present whereas in Chenopodium this is reduced to less than 2 weeks.

Rough bark, which was first observed in 1959, has been a virus disease. On affected vines many of the spurs die and the crop is reduced to almost nothing. Another of the symptoms is a weeping habit of the canes as well as the cracking of the old wood. Surveys showed it present in a high percentage of certain varieties in some Napa Valley vineyards and also in vineyards near Lodi.

With the discovery that leafroll had spread in the foundation nursery at Davis, all distribution was withheld for 1960. All foundation vines have been re-indexed and a new foundation planting will be established in the spring of 1961. Of 48 varieties that were selected, 7 have been discarded because they had vein banding virus. Some varieties such as Melon, Alicante, Bouschet, and Semillin, appear to be 100 percent infected with virus.

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16. TREE NUT CROP DISEASE CONTROL

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Problem: Develop basic and applied data which will be useful in formulation of a more effective and lower cost control program for the control of tree nut diseases.

Program: A continuing program involving basic studies on the causal organisms and their effects on the hosts and developing methods for their prevention or control. Research is at Beltsville, Md., and at Federal field stations at Albany, Ga.; Shreveport, La.; and in cooperation with the experiment stations of Oklahoma, Oregon and informally with commercial growers. This work involves approximately 3 professional Federal man-years annually.

Progress: Pecan scab. At Shreveport, La., in 1959, comparisons were made of the effectiveness of bordeaux mixture, zineb wettable powder, tank-mix zineb, Dyrene triazine, and phaltan in control of pecan scab. There was no appreciable difference in the control effected by bordeaux mixture, zineb (wetable powder or tank-mix) or Dyrene, but the control from phaltan was poor.

In central Texas complete control of pecan scab resulted from 5 spray applications of bordeaux, zineb or ziram. Approximately 80 percent of the nuts were lost on unsprayed check trees. There was some foliage injury from bordeaux; therefore the foliage was much greener and more vigorous on trees sprayed with zineb or ziram.

In Georgia, dodine (Cyprex), bordeaux mixture, zineb and ziram were used at both Albany and Fort Valley to control scab on the Schley variety. Scab counts on foliage and nuts indicated that dodine applied at the rate of 2-100 gave the best control of scab of any fungicide used. At Fort Valley, the same fungicides were used and again dodine gave outstanding results. However, tests made in 1960 show that applications of dodine even at the low rate of 1/2 pound per 100 gallons cause serious injury to certain varieties such as Moore and Van Deman and cannot be used.

In Oklahoma, in cooperation with Oklahoma State University, experiments on scab control were carried out with protective and eradicant fungicides. More applications of 13 test protective fungicides were applied with a conventional hydraulic high-pressure spray machine at 2-week intervals beginning in April and terminating in mid-August. Excellent control of scab was provided by the zineb fungicides (Parzate, Dithan Z-78, tank-mix zineb), Dyrene and dodine. Certain ziram fungicides (Zerlate, Niacide Z, tank-mix ziram), Amoban, and Dibam A were ineffective. Low-lime bordeaux mixture was effective but caused some ressetting on the nut shucks. Applications of zineb, dodine and Dyrene fungicides were found to significantly suppress the population of mites on the leaves.

In 1960, Parzate, Dithan Z-78, dodine and Dyrene with and without certain commercial stickers or surfactants on 3-week application schedule were applied in replicated experiments to 2 varieties. Preliminary scab control survey made in September showed that all fungicides had resulted in excellent disease control. The nuts on the check unsprayed trees were severely scab infected. The fungicides alone were apparently as effective as the same material plus a sticker or surfactant.

Laboratory studies on the scab fungus. In Oklahoma, it was found that colonies of Fusicladium effusum, the cause of pecan scab, grown on cultural media became very dense but the radial spread is very slow in comparison with most fungi. The largest colonies

developed on Chinese chestnut agar, Sabouraud's peptone dextrose agar and oatmeal agar.

In nutrition studies fungus plugs were placed in flasks of a glucose-asparagine-mineral salts medium amended with optimal amounts of the vitamins biotin and thiamin. Three concentrations of glucose (0.5%, 1.0% and 2.0%) and three volumes of medium (25 ml., 50 ml., and 100 ml.) were used. Half of the flasks were placed on a shaking machine. Greater growth occurred in the shaken flasks and increased as the amount of dextrose in the medium was increased. For any one concentration of dextrose, growth was greater in the 100 ml. aliquots than in the 25 or 50 ml. aliquots.

To determine the effects of light on sporulation of F. effusum new cultures of the fungus on tube slants of potato dextrose, Chinese chestnut (white) and Chinese chestnut red agars were placed in four light environments. After three weeks growth was poor in all cases but especially so in the continuous dark and continuous light sets, probably due to the high temperatures which prevailed. Very little sporulation occurred in continuous darkness. The greatest sporulation occurred on cultures under discontinuous light on white Chinese chestnut agar exposed to daily sunlight. Because copious quantities of spores are needed for investigations on physiological races of the fungus and for scab control studies in the laboratory and the greenhouse, the results of this exploratory experiment are very encouraging.

Control of foliage diseases. In Louisiana, the season of 1959 was fairly wet and favorable for development of fungus diseases on the foliage. One application of 6-2-100 bordeaux mixture applied in mid-May controlled brown leaf spot on Stuart pecan trees, but had little effect on vein spot. One pre-pollination spray application of 2-100 zineb (65 percent wettable powder) or of 2-100 Dyrene triazine 50 percent wettable powder) followed by one post-pollination application controlled brown leaf spot and gave reasonably good control of vein spot and downy spot. The foliage on the latter was much greener than that sprayed with bordeaux mixture.

On Stuart trees sprayed annually in mid-May with one application of 6-2-100 bordeaux for 4 years previously, brown leaf spot and other foliage diseases were controlled in 1959 with one application of either 6-2-100 bordeaux mixture or 2-100 zineb mid-May. This indicates a residual effect of the spray applications from year to year.

Rosette control: At Winona, Texas, zinc chelate (10 percent Zn) applied as a spray at the rate of 3 pounds per 100 gallons of water was somewhat more effective in controlling pecan rosette than was 36 percent zinc sulfate at the rate of 2 pounds per 100 gallons of water. However, the high cost of zinc chelate makes its use uneconomical as compared with zinc sulfate.

Pecan powdery mildew. In Oklahoma, powdery mildew controlling fungicides such as Karathan, Naba 25, dodine and others has been demonstrated on 18 pecan varieties without injury.

Control of Spanish moss. In Georgia, one annual spray application in each of 4 years of copper sulfate plus calcium arsenate, 4-4-100, made to dormant pecan trees infected with Spanish moss has, in that time, completely eliminated the pest.

Walnuts. Walnut blight. Weather conditions in 1959 were very favorable for the development of blight (bacteriosis) of Persian walnuts in Oregon. Chemical and antibiotic materials applied as dusts and sprays in field experiments showed that under severe disease conditions, Copper A compound, 2-100, applied in 2 spray applications gave best control of the materials tested. The Copper A compound caused a trace of injury to the leaves.

Four dust applications of Agri-mycin 500 in a formulation containing .05% streptomycin, .005% oxytetracycline and 2.5% copper, did not control the disease as effectively as 2-spray applications. Approximately the same degree of control was obtained with a copper-lime-sulfur-oil dust as with Agri-mycin dust.

In 1960, new materials tested were cupric omadine and the new formulation of Agrimycin 500. Both materials caused less walnut foliage injury than bordeaux. Agrimycin 500 gave better control of blight than cupric omadine. To date, bordeaux mixture 4-2-100 is superior in effectiveness in blight control to all other materials listed.

A striking case of resistance to blight infection was found on a local variety known as Howe in an orchard near Brownsville, Oregon. Unsprayed trees of this variety of approximately the same age on the same rootstocks and growing adjacent to similar trees of the Franquette variety showed only 0.7% infection as compared with 46.8% infection on the Franquette trees. Trees of both varieties foliate and bloom at approximately the same time; this appears to be inherent resistance rather than disease escape.

Other walnut diseases. In Oregon, studies were continued as to the cause of the disorder known as blackline and susceptibility of different Juglans species to infection by various fungi causing root rot. The work under way has yielded no new information.

In Maryland, studies and field experiments were continued on the control of walnut anthracnose. Of a number of fungicides tested, zineb was most effective; phaltan was ineffective. For effective control of anthracnose at least 4 applications of the fungicide applied at bi-weekly intervals beginning the last of May are required. There was no significant difference in the nut qualities

measured between treatments in the Stabler variety; apparently this variety bore such light crops of nuts that premature defoliation caused by the disease did not affect nutquality. Previous studies with the Ohio variety in a heavy crop year showed that nut quality was seriously affected by premature defoliation caused by the disease.

Chestnuts. Fifteen months after inoculation with the chestnut blight fungus, 93% of the Castanea dentata trees were infected, whereas only 29% Chinese chestnut, C. mollissima, were infected. C. Sativa and C. henryi were intermediate in infection with 69 and 64 percent, respectively. F₁ hybrids between the American and Chinese species showed 85 percent infection. Backcrosses of these hybrids to the Chinese parent showed 68 percent infection.

Plans. Black walnut and chestnut disease investigations at Beltsville, Md., have been discontinued. Otherwise tree nut disease investigations are to be continued along the same lines and at about the same level as in 1960. Plans for discontinuing the cooperative pecan disease work with Oklahoma and consolidation of it at Shreveport, La., did not materialize. Should funds be available, it is planned to strengthen the program at Shreveport, La., and to initiate investigations on the so-called virus disease known as bunch of pecan and hickory species.

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17. NEMATODE CONTROL

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Problem: Methods for killing nematodes in the soil before planting fruit trees are fairly well developed but a considerable amount of applied research is needed to adapt known methods of nematode control to the production of superior nematode-free planting stock and to improve the existing methods. Only a start has been made on the solution of the problem of preventing nematode-caused declines and yield reductions in established planting.

Program: A continuing long-range program of applied and basic research is conducted at Orlando, Fla.; Salt Lake City, Utah; Puyallup, Wash.; and Tifton, Ga.; in cooperation with the experiment stations of the various states. It involves about one professional Federal man-year annually.

Progress. Nematode control in a new peach orchard. An experiment started in 1959 in cooperation with the Georgia Agricultural Experiment Station and the Dow Chemical Company at Fort Valley, Ga., has shown that very good control of root-knot and root-lesion nematodes can be obtained with any one of several standard nematocides applied before planting. Young trees in the best treatments are at least twice as large as those in the untreated soil.

Preliminary nematocide evaluation at Orlando, Fla. In a continuing program of testing chemicals for nematode control, 238 new materials were evaluated during the past year. Most of these were obtained from the Entomology Research Division but some were obtained from the Eastern Utilization Research Laboratory and from

industry. Only one of these materials obtained from industry seems sufficiently good to warrant further work. Tests were also conducted on materials which appeared promising in the evaluation program in previous years but so far nothing has been found which can be recommended either for field use or for controlling nematodes in nursery stock prior to planting.

Control of nematodes on established fruit plantings with DBCP. Experiments have been made in Utah on the control of nematodes of cherries, apricots and raspberries with DBCP. While nematodes were reduced in most cases, growth was not appreciably improved.

Plans: Observations will be made on the experiment in Georgia in future years. Nematocide evaluation work will be continued at Orlando at about the present level. Further experiments with DBCP will be conducted in Utah.

F. Insect Control

18. INSECTS AFFECTING DECIDUOUS FRUITS, TREE NUTS, GRAPES AND ENT BERRIES

Problem: Deciduous fruits, tree nuts, and berries are attacked by a long list of destructive insect and mite pests. These problems have been intensified in recent years by a tendency on the part of many of these insects and mites to develop resistance to insecticides formerly highly effective against them, and increasing objection on the part of the general public and official regulatory bodies to residues of insecticides that may be present on the marketed product.

Program: This is a continuing long-range program of basic and applied research with shifting emphasis to meet various new problems relating to insects and mites that attack deciduous tree fruits, grapes, berries, and nuts. The objective is to develop safer, less costly and/or more effective treatments for protecting the respective crops attacked from damage by insect and mite pests. It includes biological and ecological studies, a search for attractants, insect sterilants, and more effective, safer insecticides; studies of insect parasites, predators, and diseases; and evaluation of available types of equipment for the application of insecticides. The work is conducted at 13 locations in important producing areas in 10 States, in most cases in cooperation with the respective State Agricultural Experiment Stations, and involves about 9 professional Federal man-years annually on deciduous tree fruits, between one and two man-years on grapes and berries and between two and three man-years on tree nuts.

Progress: Pome fruit insects. DDT and, to a lesser extent, DDT-parathion sprays are less effective than formerly in codling moth control on pome fruits in many localities. In some cases increased numbers of applications are resulting in DDT harvest residues uncomfortably close to the tolerance of 7 p.p.m., an indication that there is a limit to which growers can go to overcome the decreasing effectiveness of DDT against the codling moth by increasing the dosage and number of applications. A special synergist failed to improve the performance of DDT against the codling moth and an anti-feeding compound tested was of no value. Guthion, alone or in combination with DDT gave excellent control in tests in all areas. In bioassay studies in the Northwest, Guthion deposits remained highly toxic to eggs, larvae and adults over a 9-week period, showing greater all-round residual value than other materials and indicating a possible reduction in the number of seasonal applications needed for commercial control. Sevin was only slightly less toxic than Guthion but the efficiency of Diazinon, ethion, phosphamidon and several new experimental compounds declined markedly within 3 weeks after application.

Data on Sevin obtained in 1959 have shown that it sometimes reduces the set of apples when applied within 20 days after petal fall in the Midwest, for possibly a lesser period in the East, and a longer one in the West, and that mite populations are apt to increase to injurious levels on trees to which it is applied. Data obtained in 1960 confirmed these findings.

In Washington equivalent deposits and effectiveness against the codling moth resulted from applications of Guthion in 1, 2, 4, and 8x concentrations to moderate-sized apple trees with a conventional 45,000 cubic foot per minute air-blast orchard sprayer, at an equivalent rate of insecticide per acre. Similar results were obtained against the pear psylla on pears.

The need for an effective treatment for TDE-resistant strains of the red-banded leaf roller on apples continues. In West Virginia endrin in two applications, the petal fall and first cover sprays, gave good control of this pest. Both endrin and Kepone were ineffective when tested against an established infestation, killing only the smaller larvae. Indications are that use of endrin through the first cover spray will not result in a detectable residue on the fruit at harvest. In a complete seasonal program Bayer 29493, Guthion, and Sevin controlled the leaf roller.

In a search for a miticide that will control all strains of all species of orchard mites, there has been undertaken an accelerated screening program of promising new materials, antibiotics, and other types of compounds that might inhibit mite activity and development, and studies to determine the influence of tree vitality,

nutritional and hormone sprays, insecticides and fungicides on increases in mite populations. Several new compounds were found worthy of further study. Survival and reproduction of the two-spotted spider mite were reduced on trees deficient in nitrogen and potassium while a significant increase in egg-laying occurred following application of the hormone naphthalene acetamide (Ana Amide). There was a marked and prolonged reduction in egg-laying of three species of mites following application of the antibiotic Acti-dione. While this material is injurious to apples at an effective level it may be safe to use on peaches and raises the hope that similar materials may be found that are safe on apples. Some antibiotics were found to kill adult mites and to exert a sterilization effect on survivors.

In Indiana spring applications of miticides were generally superior to a fall dormant application for suppressing European red mite populations. No one material in prebloom or early post-bloom application schedules was outstanding. Resistance of the mcdaniel mite to Kelthane continued to increase in the Wenatchee, Washington, area, and strains of other species began to show resistance to this material in other sections. In West Virginia a "superior" oil was more effective than Tedion and Kelthane on Red Delicious and caused no injury, while an oil-Guthion combination spray gave complete control of a mixed population of the European red and two-spotted spider mites. In the Yakima, Washington area, Tedion and Kelthane continued to give good control of the mcdaniel mite and were superior to other materials tested. Good control was also obtained with Bayer 34098 and fair control with Bayer 36205. Oil sprays also showed promise. In preliminary tests of new materials in Indiana in 2 applications 3 weeks apart, two analogs of Aramite gave excellent control as did Indopal polybutene, a viscous material that acts mechanically, and Bayer 30686, a material that did not appear promising in Washington.

In Indiana the systemic insecticide phorate applied to the soil in granular form or injected into the soil in liquid form in the spring of 1959 controlled the European red mite throughout 1960. The mite population was also depressed in a plot in which the soil was treated with phorate in the spring of 1960. Indications are that such a treatment does not result in a residue in the fruit at harvest. Two new systemics SD-3562 and Monsanto CP-10502, showed promise in laboratory tests.

The pear psylla continues as a serious problem pest of pears, particularly in the West. In field tests, Guthion and Dilan were highly effective in control, dimethoate, toxaphene, and phosphamidon gave good control, and ethion and Bayer 36205 were less effective. Malathion and Shell SD-4402 gave fair to poor results. Preliminary migration studies showed movement for considerable distances during the spring but little or none during the summer.

Screening of attractants for the apple maggot, a pest for which better control measures are needed was carried on in Ohio in a search for a suitable attractant for use in a bait spray. None of the materials tested was equal to the standard protein hydrolysate-diammonium phosphate combination found in 1959.

Continued studies with the pathogen Bacillus thuringiensis and exploratory tests with B. soto indicated their relative ineffectiveness against the codling moth. Moderate-sized orchard tests of the DD-136 nematode and associated bacterium were initiated for codling moth control in the East and Midwest. Results are not yet available. Eight thousand puparia of Rhagoletes cerasi from France are available for parasite emergence for release in areas infected by the apple maggot and cherry fruit flies in 1961. Two parasite species are expected to be secured from the puparia.

Through cooperation with the New York Agricultural Experiment Station there was proved and accepted by regulatory officials the fact that controlled-atmosphere storage is an effective treatment for destruction of living stages of the plum curculio and apple maggot, thus permitting shippers to move apples from such storages in infested areas into uninfested areas protected by quarantine regulations.

Stone fruit insects. The plum curculio, borers, mites, and sucking bugs are among the more destructive pests of peaches and other stone fruits for which more effective, less expensive, or safer treatments are needed. In screening tests in Georgia, Bayer compounds 29493 and 25144 and dimethoate were the most promising of the many compounds compared for plum curculio control. In field tests Bayer 29493 was superior to parathion and Sevin. The Bayer compound at 4 pounds of 25 percent wettable powder per 100 gallons in the early season applications damaged fruit and foliage but at 2 pounds per 100 gallons in the last two applications caused no injury. In field tests on plums in Ohio, Guthion was highly effective in plum curculio control but only slightly superior to dimethoate which was in turn superior to Shell SD-5539 and methyl Trithion. Some injury resulted from use of all but the Shell compound. In Georgia, soil applications of chlorinated hydrocarbon insecticides continued to control the plum curculio several years after application. Aldrin, dieldrin, and heptachlor, with chlordane close behind, appear to be the most effective materials for such use. Type of formulation appears to be unimportant.

In tests on peaches in Indiana, Guthion was superior to Sevin for general insect control and sprays were superior to dusts, except Sevin was superior to Guthion against the leaf roller Playnota flavedana. Finish of fruit in the spray plots was superior to that in the dust plots, primarily due to the use of sulfur as the fungicide with the dusts and captan with the sprays. On peaches, there was no evidence in Georgia or Indiana that applications of Sevin started

at full bloom, petal fall, or shuck-split, affected fruit set.

The peach tree and lesser peach tree borers remain as serious pests of peaches in many producing areas. In continued tests in Georgia, endrin and Thiodan were outstanding when used in trunk sprays to prevent infestation. Dieldrin was also promising, while Sevin, the systemic insecticide phorate applied to the soil, and the insect pathogens Bacillus thuringiensis and the DD-136 nematode were ineffective. In Indiana, endrin, dieldrin, Guthion, Sevin and Thiodan sprays controlled both the peach tree and lesser peach tree borers, and spot treatments of dieldrin, endrin, or malathion controlled the lesser peach tree borer. Applications of the materials as sprays were superior to applications as paints. Spot applications of B. thuringiensis were ineffective.

In general the miticides found effective for the protection of pome fruits from mites are equally effective on stone fruits. Indopal polybutene, promising for early season use to control mites on apples in Indiana, caused severe chlorosis of peach foliage when used in a single application in August. In West Virginia, Kelthane gave complete control of the peach silver mite, but a summer oil alone or with Guthion was unsatisfactory.

The bait sprays found effective for controlling tropical and subtropical fruit flies should be equally effective against temperate zone fruit flies, as the apple maggot and cherry fruit flies, but preliminary tests have not given promising results thus far. In Ohio, bait sprays containing a protein hydrolysate with malathion and the fungicide Cyprex failed to protect sweet and sour cherries from cherry fruit flies. Fly populations were depressed by the sprays for a few days but returned to a high level within 7 days.

Pecan insects. Basic studies were continued in Florida on the hickory shuckworm as a basis for the development of a satisfactory method of control, particularly with emphasis on production of the insect in the large numbers needed for a sustained laboratory research program on lures that might be sufficiently attractive to be used alone or in bait sprays for control. Significant improvements have been made in rearing the larvae and obtaining eggs but not yet enough for practical purposes. Screening tests in an outdoor cage revealed 16 of 49 candidate materials worthy of field trial as lures, but field tests later failed to yield any promising lures. There was confirmed in replicated field tests the considerable and about equal value of EPN and Guthion, and their superiority to Sevin, for shuckworm control after the nuts begin to harden. Neither of the insect pathogens B. thuringiensis and DD-136 nematode showed promise for shuckworm control.

DDT, toxaphene and other materials applied to the trees give good control of the pecan weevil but many small growers are not equipped

to make the necessary applications. To meet their need, soil treatments of granulated chlorinated hydrocarbon insecticides are underway in Georgia, without conclusive results to date.

The pecan nut casebearer, well-known as a problem pest to most pecan growers, was more abundant than usual during the year, providing an opportunity for an expansion of studies on its control. In Florida, a single application of parathion by helicopter gave as good control of an extremely heavy infestation as applications from the ground with hand guns or an air-blast sprayer. In Louisiana, conventional applications of Guthion, Sevin, Diazinon and Thiodan gave good control, Guthion being slightly superior to the other materials. Under conditions of heavy infestation an aerial application of parathion plus DDT was superior to one of malathion but both aerial applications were definitely inferior to conventional applications from the ground.

The pecan leaf casebearer, cigar casebearer and a sawfly are on the increase in pecan orchards in the Southeast, particularly the leaf casebearer. Aerial applications of a 5 percent malathion dust at 20 pounds per acre in Georgia gave good control of exposed immature leaf casebearer larvae but many mature larvae in cases survived. A liquid formulation applied by plane at a rate to provide $2\frac{1}{2}$ pounds malathion per acre killed all stages. The minimum amount required for good control remains to be determined.

In continuing studies of spray residues on the ground cover in pastured pecan orchards, deposits of toxaphene on forage under sprayed pecan trees ranged from 488 to 672 p.p.m. immediately after spraying. The rate of weathering indicated that it would take well over 100 days for the residue to decline to the tolerance of 7 p.p.m.

There is no need for determining the effect of certain aphids, especially the black-margined pecan aphid, on pecan trees as a basis for reaching a decision on the need to control outbreaks. Cooperative studies with the Crops Research Division have revealed the need for a more effective treatment before satisfactory progress in such a determination can be made. Demeton and schradan were more effective in controlling aphids on isolated trees than on those near infested, untreated ones.

Grape insects. Moderate to light infestations of the grape berry moth, commonly the most serious pest of grapes in the East, were controlled effectively with concentrate sprays applied at the rate of 75 gallons per acre with an experimental air-blast machine under development in cooperation with the Agricultural Engineering Research Division. An all-season schedule of Sevin with Phaltan fungicide or with captan early in the season and copper fungicide later was as effective as a DDT-parathion-captan schedule with malathion-copper-lime in the last application or as a DDT-parathion schedule with captan and a copper fungicide.

Various galls sometimes occur in vineyards in tremendous numbers causing great concern. Satisfactory treatments are not known for most insect species responsible. In Ohio, a prebloom and 4 post-bloom applications of Guthion, dimethoate, or malathion in addition to the regular DDT-parathion program, all effected a material reduction in the numbers of grape tomato galls formed and caused no injury. In another test phorate applied to the soil reduced the number of grape tomato galls formed on the treated vines to almost zero.

Various species of *Drosophila* infest ripening fruits, annoying pickers and handlers and leading to contamination of processed products. In the search for an effective attractant for use in control alone or with an insecticide there has been screened during the past year 100 miscellaneous chemicals, over 1100 sample materials from the laboratories of the Western and Northern Utilization Research and Development Divisions. None of the materials showed outstanding promise. Only a few equalled or exceeded the standard which is only moderately attractive.

Berry Insects. In eastern United States the Japanese beetle often occurs in maximum numbers during the blueberry harvest period, giving rise to the need for an effective insecticide to prevent damage without leaving an excessive residue. In New Jersey, Sevin at 1/2 or 1 pound per 100 gallons gave good protection for 7 days, permitting damage to only 13 and 4 percent of the fruit, respectively, as compared to 90 percent on unsprayed plants.

In California, soil injections of phorate and Di-Syston prior to planting strawberries, in December, 1959, gave adequate commercial control of spider mites until May 31, 1960. Dimethoate and demeton were less effective, as were foliage applications of phorate, dimethoate and demeton in May. Residues, .02 to 0.3 p.p.m., of the materials used in soil applications were found in strawberries picked April 21, showing the need for the establishment of small tolerances for them before they can be used on a commercial basis.

Kelthane continues to be the most effective foliage spray for two-spotted spider mite control on strawberries during harvest. Demeton, Trithion, and Diazinon seem to be losing their effectiveness. Promising new materials include Tedion, Bayer 28589 and Geigy G-30494. A combination of Kelthane with Tedion alone or with oil is also promising. The effectiveness of Kelthane was increased by the addition of an oil emulsion to the spray, 1 quart per acre of the oil being as good as larger quantities. Oil alone at 1, 2 or 4 quarts per acre was ineffective.

A serious infestation of the raspberry root borer in Maryland led to tests of phorate, Di-Syston, and dimethoate applied in holes

near the crowns of the plants for control. Results were poor, the treatments failing to kill either young larvae that hatched, in 1959 or half-grown larvae that had hatched in 1958. Adult emergence in September and October indicated a need to postpone present recommended spray dates to coincide with the hatching period of the young larvae.

Plans: Investigations will be continued at a slightly increased level, new funds permitting increased emphasis on research with insect pathogens and sterilants for codling moth control, on systemic insecticides for controlling apple insects, and on research on pecan insects, particularly to initiate studies on the pecan leaf casebearer. There will be continued emphasis on studies of resistant strains of orchard pests, particularly mites, and on methods for preventing or combatting them; on work with methods of control that will permit a reduction in the use of highly poisonous insecticides; on the introduction and distribution of promising parasites and predators as they become available; and on the evaluation of available types of insecticide application equipment.

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19. INSECT VECTORS OF FRUIT DISEASES

ENT

Problem: Deciduous fruits, tree nuts, grapes, and berries are attacked by an increasing number of virus diseases or complex mixtures of virus diseases, which either kill the trees, vines, or plants outright or cause them to suffer serious declines in vigor and productiveness. Many of the virus diseases are known

to be transmitted by insects and mites; such a relationship is being proved in an increasing number of cases. Control of the insect vectors may in many cases aid in controlling the diseases. In any event, knowledge of the insect vectors aids greatly in understanding the diseases they transmit.

Program: A long-time continuing program to determine what insects and mites transmit virus diseases of deciduous tree fruits, small fruits, and berries; to study the biology, habits and host-range of the variety of insects found to transmit these diseases; and to develop methods for controlling the insects. Present emphasis is on stone fruit virus diseases with exploratory work on pear decline. The work is carried on in California, Georgia, Oregon, Washington, and Wisconsin, in most cases in close cooperation with the respective State Agricultural Experiment Stations and Crops Research Division. The work involves four professional Federal man-years and the part-time services of four cooperating State workers or graduate students.

Progress: Peach mosaic vectors. There has been discussed in earlier reports the fact that in the areas to which peach mosaic virus has long been confined, one species of eriophyid mite has been found to be apparently the only transmitter; also, that this species has been found to extend eastward from the limits of peach mosaic in East Texas at least to Georgia. It is of interest to quarantine and disease-suppression agencies that this mite has not been found in northern California, the Pacific Northwest, nor Midwest where considerable searching has been done. In 1960 a special detection survey again failed to locate the vector species in the mosaic-free areas of California, Oregon, and Washington north of long-infected districts of southern California. There have been tangible and important results of this detection work, however, in the finding that while the peach mosaic-transmitting species, as precisely described, has not been found in these northern areas, a number of very similar mites on different rosaceous trees or shrubs do occur there. Work is in progress, as yet incomplete, to determine whether certain of these mites may (1) be actually the mosaic vector species, or (2) be closely related and capable of transmitting peach mosaic virus if it were to be introduced and become available to them. At least eight such forms of eriophyid mites have been found on eight common woody plants. In transmission studies with the vector mite this year it was found, contrary to earlier conclusions, that certain cherries may be hosts of peach mosaic. Bud-inoculation of infected peach tissue into cherry has never produced infection in the cherry.

Vectors of latent viruses of stone fruits. The search for the unknown vectors of the complex of latent viruses of stone fruits, particularly of the ring spot virus in most stone fruits and the sour cherry yellows, proceeded in Oregon and Wisconsin in

cooperation with the State Experiment Stations. Experiments have been completed with nearly all the prevalent species of leafhoppers, aphids, thrips, and whiteflies. Mites are not considered to have been thoroughly tested. No transmissions have been secured. There is clear evidence now that detection of transmitters of these viruses, if indeed arthropod vectors do exist, is to be an arduous and difficult vector search problem.

Increased attention has been given to studies with plant pathologists to determine whether pollen can be the avenue of spread. These studies have given inconclusive results to date.

In a continuing spray experiment in Wisconsin to control the unknown vector or vectors of necrotic ring spot and sour cherry yellows in sour cherries, spread was slower in the treated than in comparable untreated blocks, but results were inconclusive because conditions were poor for expression of yellows symptoms.

Vectors of cherry mottle leaf virus. In 1959 there was found for the first time a microscopic eriophyid mite living on cherry mottle leaf virus-infected wild bitter cherry trees at Wenatchee, Washington. It was this year proved to be a vector of the cherry mottle leaf virus, 12 cases of transmission occurring in 21 tests. The mottle leaf disease is important in sweet cherry orchards in Washington and Oregon. Spread at The Dalles, Oregon, this year increased in orchards with no wild cherries in the vicinity, an indication of sweet cherry to sweet cherry spread. While this mite is often common in the bitter cherry, considerable searching was necessary to find it in sweet cherry orchard trees. The fact that it does occur in sweet cherry was finally established, and thus there can be postulated its serving as a vector in orchards away from wild cherry stands.

Phony peach virus. Airplane application of $1\frac{1}{2}$ to 2 lbs. of DDT per acre of woodlots adjacent to peach orchards controlled the primary natural vector, Homalodisca coagulata, of phony peach in the woods where they hibernate overwinter and prevented movement of the insects into the orchards. The natural or normal pattern of incidence of spread of phony in a young orchard was broken as a result of the spray program. Normally the number of diseased trees in an orchard increases annually until a peak is reached in the fifth year. In the experimental orchard there was a sharp reduction in the number of phony trees in the fifth year. This reduction was correlated with the low vector population in the orchard as a result of the spray program in the adjacent woods. The current preferred spray program involves two applications of DDT, one about April 1 and one about May 1.

Preliminary screening tests showed that the systemic insecticides phorate (Thimet) and Di-Syston are highly toxic to the phony peach

vectors. Use of such poisons in young orchards prior to bearing offers much promise of disease prevention during the most susceptible period of the peach tree to phony infection. Di-Syston was less phytotoxic to nursery stock peach trees than phorate. Dosages of 5, 10, and 15 grams of Di-Syston per tree in the form of granules applied to the base of such trees killed experimental vectors caged on the trees from June 20 to September 15, 1960. It appears that one treatment might protect the trees for an entire season.

Pear decline disorder. The growing acceptance of the belief that a virus may be associated with pear decline prompted an effort now underway in California to establish test trees suitable for vector studies. There has also been close cooperation with research workers in other disciplines in California in initiating an all inclusive study of the pear decline problem. It is possible that transmission could be accomplished by a vector in advance of transmission by the usual mechanical techniques.

Plans: Most of the program will be continued along the same lines and at about the same level as in 1960 but with some reduction in work on peach mosaic and cherry mottle leaf virus vectors to initiate exploratory vector tests of pear decline. There will be emphasized (1) efforts to produce the peach mosaic vectors in numbers for use as a research tool and in studies on its control, (2) studies to clarify the species status of the complex of eriophyid mites similar to the peach mosaic vector, (3) initiation of a search for possible vectors of pear decline, (4) control of phony peach vectors, (5) a continued search for vectors of the latent viruses (ring spot, sour cherry yellows, etc.) of stone fruits, and (6) initiation of studies on the control of the new-found vector of cherry mottle leaf virus.

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20. PEST CONTROL EQUIPMENT

AE

Problem: The cost of pest control machinery, materials, and their application is an important item in the total cost of producing fruits and edible tree nuts. In order to reduce these costs there is need for more effective and efficient equipment and methods of application of pesticides with aircraft, surface, and soil working machines.

Program: A continuing long-term program involving laboratory and field studies, conducted with headquarters at Forest Grove, Oregon; Wooster, Ohio; Beltsville, Maryland; and Ames, Iowa, in cooperation with State Agricultural Experiment Stations of Washington, Oregon, Ohio, and Iowa, involving about four professional Federal man-years annually. Work at these locations, while not on fruit and tree nuts directly, is applicable to the problem.

Aircraft Equipment for Application of Pesticides. A series of tests was conducted to determine spray penetration and deposit resulting from aerial application to certain crops. The dye recovery method was used to determine rates of deposit on the sampling areas. Pressure adhesive labels $1\frac{1}{2}$ " x 1" were attached to the leaf surfaces and used as sampling areas. Labels were placed on both the top and under surfaces of leaves at various foliage levels. Tests on potatoes indicated that spray was deposited at the upper and lower plant levels and on both leaf surfaces in varying degrees depending upon position on the plants. The highest deposits were at the top of the plants with reduction in deposit and coverage toward the ground. Similar results in general were found in tests on pole beans and corn. Some individual tests with the N3N biplane with and without the use of a spoiler mounted under the center of the fuselage in various positions indicated that the normal crossover of spray from right of center to left of center could be controlled by properly positioning a spoiler. Replicated tests using the same spoiler position and nozzle arrangement, however, showed that variations in swath patterns were as great as the differences found in patterns with and without the use of a spoiler.

Spray Atomization and Relation to Pest Control. The object of this project is to determine the effect of the drop size of a spray pattern on the pesticidal results obtained in the application of agricultural sprays. The field experiments were done in cooperation with the Department of Botany and Plant Pathology, Ohio Agricultural Experiment Station. Fungicidal sprays of controlled mass median diameter were applied to randomized, replicated tomato plots. The fungicide, Manzats, was applied at half the recommended rate to intensify differences in disease infection. Effectiveness of spray treatments was measured by net yield, anthracnose and early blight infection on fruits and per cent defoliation. Two series of flat spray patterns ranging from about 100 microns to 500 microns mass median diameter were applied. One series was applied at 40 gallons per acre and the other at 15 gallons per acre. Mass median diameters were varied by 100 micron increments by changing spray pressure. A similar series of hollow cone sprays ranging in mass median diameter from about 100 microns to 400 microns was applied at 40 gallons per acre. Differences in disease infection and yield were not significant and show little relation to drop size for any of the spray patterns or application rates used in the experiments. The lowest per cent defoliation occurred in the plots sprayed by a hollow cone pattern of small mass

median diameter.

Aerial Spray Equipment for Forest Insect Control. Studies on the development of aerial spray equipment and operational procedures for more effective control of forest insects were conducted cooperatively with the Division of Forest Insect Research of the Forest Service. Headquarters are at the Forest Insect Laboratory at Beltsville, Maryland. In the atomization studies, estimating the mass median diameter (mmd) of a spray sample by measuring the spots, produced on paper cards, of five of the largest drops in the spectrum was as accurate as the much longer method of measuring each drop on a given unit area. The use of a black-dyed spray on white cards was found to be superior to undyed spray on red-dyed cards for determining atomization.

The effect of airplane speed on spray atomization with a nozzle commonly used on Piper and Stearman planes (Spraying Systems T8010) showed that doubling the airspeed (80 to 170 mph) reduced the mmd of the spray 50 percent (162 to 82 microns). With a nozzle commonly used on a larger aircraft (Spraying Systems U50120) increasing the speed from 150 to 200 mph reduced the mmd of the spray from 187 to 146 microns. The effect of type of spray outlet on spray atomization with a TBM at 170 mph with outlets directed down 90 degrees to the thrust line of the plane was also studied. Using nozzles delivering from 3.8 to 10 gpm per nozzle the mmd ranged from 116 to 150 microns.

Spray distribution and atomization test flights were conducted with a Bell 47-D1 helicopter. Three flights were made at a height of 25 feet and two at 50 feet. The lower flight altitude of 25 feet resulted in a wider and more uniform deposit than the 50-foot altitude in these limited tests. On the average, a swath 100 feet wide was covered at a deposit rate of .25 to .3 gpa. The atomization produced by small hollow cone nozzles on this aircraft was about 137 microns mmd.

Equipment for Application of Chemicals to Soil for Control of Soil Pests. The object of this project is to develop equipment and techniques for the chemical treatment of soil for the control of pests in orchards, forest nurseries, ornamental plantings, vegetables, and other crops. The field experiments were done in cooperation with the Department of Botany and Plant Pathology and Department of Entomology, Ohio Agricultural Experiment Station. Liquid and granular forms of nematocides, herbicides, insecticides, and fungicides were applied to soil in which various crops including vegetables, ornamentals, locust tree seedlings, tobacco, and grape cuttings were grown. Thirty-six different formulations alone or in combinations with each other were used during the season. Nylon, teflon, stainless steel, neoprene, polyethelene, and bronze materials have given good service in the application equipment used in making these treatments. The field cultivator with spring-type shanks proved to be readily adaptable to row treatments and easily set up on a tool bar for different full width treatments.

The full width and row-type rotary tiller also met field requirements very well. A device for laying plastic film to retain a highly volatile fumigant as it is applied was prepared for use with these applicators and used at several locations during the season. Two of the field cultivator shanks were mounted on a short tool bar for the application of soil treatment chemicals to single rows of living ornamental plantings. Initial data on this method of treatment show excellent nematode control.

Weed Control Machinery. The use of granular herbicides has increased at a rapid rate during the past two years. Studies were conducted in cooperation with the Iowa Agricultural Experiment Station to evaluate various granular formations and to determine the methods and equipment required for accurate and efficient application. As pre-emergence treatment a granular formation of 2, 4-D, Randox, Simazine, and Eptam was as effective as liquid formulations. Clay carriers (Attapulgit, Pikes Peak, and Bentonite) had little or no effect on control. Granular size as measured by U. S. Sieve No. (30/60, 24/48, 20/40, and 15/30) showed no significant differences in the weed control obtained. Tests with various percentage formulations (5%, 10%, 20%, and 25% for 2,4-D; 6.25%, 10%, 12.5% and 25% for Randox; and 4% and 8% for Simazine) showed no large differences in weed control. These granular size and percentage formulations studies indicate that uniformity of distribution is not highly critical. Laboratory trials where granules were caught on glass plates show that all of the commercially available spreading devices could be improved. Working granular herbicides into the soil with a rotary hoe at application time did not materially affect the weed control obtained. Evaluated in terms of weed control in the field, flutes, augers, fluted shafts, gravity feeds, and reciprocating chains are some of the mechanisms that will satisfactorily meter granular herbicides. Fan-type spreading devices, inverted cones, and splash-plates were used to obtain uniformity of spread of granules on the soil surface. Approximately equal weed control was obtained with all spreading mechanisms.

Small Particle Behavior. A study was continued to provide basic theoretical concepts and experimental data needed for development of pesticide application equipment and techniques which have optimum depositing efficiency and distribution characteristics. Because of the effect of particles upon each other, it has been found that behavior of groups of particles cannot easily be predicted from the behavior of single particles. A study has been initiated which attempts to describe particle behavior from a statistical point of view.

A scanning type of instrument is under development for measuring the distribution of chemicals on plants. An intense beam of

ultraviolet radiation is directed upon a rotating cylinder or disk upon which the treated sample is to be mounted. The visible fluorescent light emitted is sensed by a microscope-microphotometer system, and the signal is fed into an appropriate recorder. An instrument enclosure and ultraviolet illumination system have been designed and constructed.

Plans: Improved granular dispensing equipment for aircraft will be developed and tested. The technique of spray deposit measurement by adhesive labels will be developed further. The accuracy of metering and spreading of granular herbicides required for efficient and economical weed control will be investigated. Study of small particle behavior will be extended.

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"Hand Sprayers and Dusters" - Frank Irons. USDA Home and Garden Bulletin No. 63, December, 1959.

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21. MECHANICAL AIDS IN HARVESTING AND ORCHARD HANDLING

AE

Problem: With the growing shortage and increased cost of hand labor for harvesting and farm handling of fruits and tree nuts, there is an urgent need for the development and improvement of

machines and methods that will reduce the amount of labor required and still maintain acceptable market quality.

Program: A program of both basic and applied research involving the reduction of labor costs for harvesting and farm handling of deciduous fruits is being conducted in East Lansing and South Haven, Michigan; Wenatchee, Washington; and Davis, California, in cooperation with the respective Experiment Stations in those states, the Eastern Utilization Research and Development Division at Philadelphia, Pennsylvania, producers and machinery manufacturers at four locations in three States, and involving five professional Federal man-years annually.

Progress: Harvesting is the only step in the growing, handling, and packing of apples that has not been extensively mechanized. It is a major problem because of high cost, periodic shortages of labor, and difficulty of harvesting the entire crop at proper maturity and, therefore, growers in all apple producing areas need techniques and methods which will make harvesting easier and less costly. Conclusions drawn from research to date are as follows: (1) The tractor-mounted picking and pruning boom constructed last year did not function satisfactorily under field conditions. The drive mechanisms were redesigned, constructed, and successfully tested for mechanical performance. (2) A hedging machine for deciduous fruit trees was designed and constructed. The unit was tested in a commercial orchard and produced satisfactory hedging results. (3) Apples destined for juice markets were harvested with a boom-type tree shaker and placed into field containers at a labor cost of 2-1/2 cents per bushel compared to 15 to 25 cents per bushel usually paid to hand pickers. The 5-man crew harvested 517 bushels of apples in 2 hours. (4) Preliminary tests of a Steel Squirrel (self-propelled elevating platform) equipped with a funnel, conveyor tube, and bulk box indicate that this combination of equipment might increase picking rates by 90 percent. (5) Time studies showed that dwarf apple trees can be hand picked at an average rate of 15 percent faster than standard trees.

The bulk-box handling methods developed under this project for apples, pears, and clingstone peaches have become standard practice in all major deciduous fruit producing areas of the United States and Canada. It is estimated that during the 1959 season over 30 million bushels of fruit were handled in bulk boxes with a resultant saving to the industry of over \$1,000,000. In cooperation with Michigan State University, a water floatation unit for emptying apples from bulk boxes was designed, constructed, and tested. This unit has been in constant use during 5 months of packing and the results showed that most of the bruising and stem punctures that normally occurred during the dumping operation were eliminated.

Help was given the Forest Laboratory, Madison, Wisconsin, in obtaining 10 representative bulk-box designs used in the Pacific Northwest. The Forest Products Laboratory is testing these designs for strength and durability.

Research in commercial groves showed that fresh prunes can be handled safely in 24-inch deep bulk boxes provided they are not allowed to stand for longer than a 24-hour period. Studies showed that Stanley plums can also be handled in bulk boxes. Indications are that there will be a rapid changeover to bulk-box containers for both these crops. Followup studies of the use of bulk boxes in connection with mechanical harvesting will be made next year.

Blueberries are grown commercially in the Mid-Atlantic States, Great Lakes area, and the Pacific Northwest. Fifty percent of the cost of producing blueberries is paid to the workers who harvest the crop by hand. Commercially-made equipment using the harvest principles developed on this project last year was employed extensively in commercial plantings during the past season. More than 850,000 pounds of cultivated blueberries were picked with machines. Studies made of both commercial and controlled harvesting operations showed that mechanical picking reduced harvest costs by 50 percent (from 8 cents to 4 cents per pound) and reduced labor required for picking by 70 percent. Considerable progress was made on the development of a continuous-type mechanical harvester. Although none of the continuous harvester modifications have been entirely successful, the latest model used at the close of the season showed promise.

From one-third to one-half of the gross returns from both sweet and sour cherries are paid to the workers who harvest the crop by hand. These workers are becoming increasingly hard to recruit; a situation which exists in all cherry producing areas. Detailed time, quality, and cost data were taken on 28,652 pounds of sour cherries harvested mechanically from 511 trees in 8 commercial cherry orchards. Six different fruit-catching frames were evaluated and three handling methods used. Results showed that 95 to 98 percent of the fruit could be removed at an average labor cost of 75 cents per hundred pounds and an equipment cost of 65 cents per hundred pounds. Seven men operating the harvest equipment were able to do the work of 33 hand pickers. The work showed that cherries can be harvested without detriment to quality when operator care and proper equipment are used. As a result of the findings of this project approximately 30 growers in the State of Michigan will harvest sour cherries mechanically next season.

Additional chemical spray materials were tested for loosening sweet-cherries on the tree. One of these materials increased the

rate of fruit recovery from 65 to 95 percent. A comparison was made of brined samples of hand-picked and machine-harvested sweet cherries. The results show that the quality of machine-picked fruit was satisfactory. The mechanically harvested sweet cherries had 52 percent attached stems which offers the possibility of using them for the premium "cocktail pack."

Time, cost, and quality studies were made on the mechanical harvesting of 8,760 pounds of Stanley prune plums. The equipment developed for harvesting cherries was used in this study. The results show that 93 to 99 percent of the plums can be separated from the trees at the rate of 10 trees per hour with a 4 man crew. All of the machine-picked plums met acceptable grade standards. Several improved fruit catching units and two new-type tree shakers are being constructed and will be tested next season. Chemicals which showed promise for loosening sweet cherries will be given more extensive trials.

About 225,000 tons of Concord grapes are produced each year in the six States of New York, Michigan, Washington, Pennsylvania, Arkansas, and Ohio. Conventional harvesting and handling methods are expensive and cause considerable damage to the raw product. Two chemical defoliant materials were applied in three concentrations to grapes in an effort to remove the vine foliage for increased visibility in picking. Neither of these chemicals was effective for defoliating Concord grapes. These same chemicals were studied for their effect on the shelling of the grapes from the bunches. The vibrating shaker head developed for blueberries was used to mechanically harvest the experimental plots. Results show that grapes can be harvested mechanically as individual fruit at 2-1/2 times the rate of picking bunches by hand. Since 91 percent of the Concord grapes produced in the United States are pressed into juice, this method of harvesting and handling individual grapes shows promise. The defoliant chemicals used in the trials were not effective in preventing splitting as the grapes were removed. Forty-five to fifty percent of the grapes were cracked with a resultant juice loss.

A study was made of pallet-handling grape boxes from the vineyard using tractor-lift equipment. Only one-half as many man-hours were required to load grape boxes on pallets in the vineyard and transfer the pallet to the road truck as were required with the conventional method of loading the boxes on a trailer and then transferring each box by hand to the road truck. Thirty shallow pallet boxes (54" x 47" x 19") were designed and used experimentally to handle grapes from the vineyard to the processing plant. These boxes were filled in the vineyard and stockpiled with tractor-lift equipment on bolsters at a farm-loading area. A Clark-Ross Carrier straddle truck was used to move unit loads of 15 pallet boxes to the processing plant. Results show that Concord grapes can be

handled in shallow pallet boxes without loss of quality.

Although mechanical harvesting of prunes for dried fruit outlets is being adopted by the industry, better equipment and methods are needed to further reduce harvesting costs and labor. Twenty pickup machines using the principle developed on this project were manufactured and used by growers. Studies showed the average rate of harvest was approximately four times the rate of hand pickup.

Studies in commercial orchards of the low-profile collecting frames, developed on this project last year, showed that their use reduced labor requirements by 75 percent and cost by 50 to 60 percent in harvesting prunes with boom-type shakers. Four manufacturers are building collecting frames patterned after this unit for sale this coming season.

Equipment was developed to determine the feasibility of using pulsating airblasts for harvesting fruit in the coastal areas where prunes loosen as they mature.

Harvesting methods and equipment on olives, almonds and figs are not entirely satisfactory. For example, olives are still picked by hand. Units for picking up almonds and figs from the ground are inefficient. The pickup machine developed for prunes was modified with a nylon bristle pickup roll and worked satisfactorily for almonds and figs. However, further improvements are needed. An experimental high frequency (3000 cpm) shaker was tried on olives.

Hand labor for harvesting Clingstone and Freestone Peaches, and Apricots has become difficult to recruit. Mechanical harvesting equipment developed for prunes was tested on these crops. Bruising was excessive and per-man hour output was only slightly greater than picking by hand.

Plans: Studies will be continued on the hedging, dwarf tree harvesting, experimental shaking, and other picking aids having to do with apple harvesting in order to get some indication of the most logical methods for recommendation.

The work on bulk-box handling of tree fruits is completed and will be closed out.

A continuous type harvester for blueberries will be modified and further tested. Work will also be continued on the development of a farm picking unit for blueberries.

Several improved fruit catching units will be tested and at least two new type tree shakers will be constructed and tested which may have application in the harvest of sweet cherries, prunes, and

peaches as well as sour cherries.

The use of certain chemicals which showed promise for loosening sweet cherries will be given more extensive trials.

Defoliation, fruit loosening, mechanical harvesting and handling studies will be continued on an expanded scale with Concord grapes.

Some studies on the use of pulsating air for fruit removal will be further tested.

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II. UTILIZATION RESEARCH AND DEVELOPMENT

A. Chemical Composition and Physical Properties

1. CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES

WU, EU

Problem: Deterioration of color, flavor, texture and nutritional elements in processed fruit and nut products limit their utilization and can be the cause of serious losses to farmers and processors. Knowledge of the composition of the raw material in the processed products is necessary in order to make intelligent evaluation of quality and to devise better methods to retain or improve quality.

Program: A continuing long-term research program on studies of the composition of fruit and nut products is being conducted. It involves 8 professional Federal man-years per year at WU and 3 man-years at EU. Research is also being conducted under P.L. 480 at the Agricultural Research Station in Rehobot, Israel and at the Experiment Station for Food Preserving Industries in Parma, Italy.

Progress: Enzymatic Browning: Research on substances involved in the enzymatic darkening of frozen peaches has been continued with the ultimate objective of finding more effective ways to prevent darkening than is now possible by adding ascorbic acid.

It has been shown that chlorogenic esterase inhibits enzymatic browning of cut surfaces of peaches by breaking down chlorogenic acid into caffeic and quinic acids. Further studies have shown, however, that caffeic acid subsequently polymerizes forming colored products on the cut surfaces. Our search for other agents that may break down chlorogenic acid forming stable products has resulted in the discovery that *Pseudomonas fluorescens* transforms chlorogenic acid into caffeic acid, and caffeic acid into a product almost lacking in fluorescence. Loss of fluorescence is indicative of ring cleavage which is felt to be necessary for a satisfactory degradation of chlorogenic acid to a nondarkening compound.

Volatile Flavor Constituents of Strawberries: Research on flavor constituents of strawberries has been completed. This research was aimed at an understanding of the changes occurring in processing of strawberries. It has been of long-standing interest to strawberry breeders who need objective means for evaluation of flavor on a small number of berries.

Many improvements in gas-liquid partition chromatography have been accomplished in this research. A capillary apparatus for the ultra-micro analysis of the various fractions from ordinary gas chromatography and for careful examination of original flavor oil has been built. This instrument shows well over a hundred components in strawberry flavor fractions boiling below 200° C., in addition to a number of components boiling up to 270° C. Experiments have

shown that methods of "internal standardization" can be used to identify many of these components even though the total sample load is 25 micrograms. So far some 40 substances have been conclusively identified. Of these, two very important ones, trans-2-hexene-1-ol and its acetate, have not previously been isolated from natural material. It was found that the trans-2-hexene-1-ol is rapidly converted by enzymes in crushed strawberries to a corresponding aldehyde, trans-2-hexenal. The formation of this aldehyde, which represents a flavor deterioration, does not occur in frozen or heated whole berries when they are crushed.

Work on strawberry flavor has been discontinued so that all available effort can be placed on the study of flavor stabilization in powders made by the new foam-mat drying process.

Chemistry of Sulfur Dioxide in Dried Fruit: Sulfur dioxide (SO_2) has long been used as a preservative for dried fruit. However, its flavor is objectionable to many consumers and some foreign markets are closed to fruit products preserved with this compound. Information is needed on the fate and mode of action of sulfur dioxide in dried fruits as a basis for the development of improved or alternative means for retarding deterioration in these products.

As a necessary first step in this research the analytical methods now in use have been compared. These are the gravimetric, direct titrimetric and colorimetric methods. Several modifications of the gravimetric method were checked and it was found that the official AOAC method gave low results. A simpler direct titrimetric method gave higher results than the AOAC method. The colorimetric method for SO_2 determination also gave satisfactory results. Thus rapid convenient methods for assay of free and bound SO_2 have been provided.

Free SO_2 and SO_2 bound to sugar in dried fruits have been shown to disappear during storage in the absence or in the presence of oxygen and to be involved in the formation of as yet unidentified compounds which are stable to alkali and acid hydrolysis. It has been postulated that these stable compounds are sulfonic acids. A search for a suitable specific detection procedure for sulfonic acids is now underway.

It has also been postulated that SO_2 in a sugar medium will break down to elemental sulfur. Such a reaction offers a possible explanation for the SO_2 losses in the storage of sulfited dried fruit. Experiments have therefore been undertaken to find evidence whether such a reaction leading to the formation of elemental sulfur occurs in the storage of dried apricots. Two sensitive methods for detection of sulfur were applied and these indicated the absence of elemental sulfur in brown apricots. This absence means either that no elemental sulfur is formed in storage of sulfited dried apricots, or that if formed, the elemental sulfur disappears by subsequent reaction. To test for the latter possibility, 0.10% elemental sulfur was added to dried apricot

puree. This puree, and a control puree with no sulfur added are being stored at 100° F. and tested periodically for elemental sulfur by the procedures developed. After 40 days storage, elemental sulfur has been found to be still present in the apricot puree to which it has been added. An attempt is being made to develop a semi-quantitative method for determining very small quantities of sulfur. It has been found by measurements on the Hunter-Gardner Color Difference Meter that the puree to which elemental sulfur was added lost redness, became darker, and became yellower, and the color became less saturated at a faster rate than the control puree with no added sulfur.

Physiological Factors in Processed Prunes: About 30% of the dried prunes used in this country are consumed in the form of prune juice. This is very beneficial to the dried fruit industry since prunes used for the production of juice are small sizes that are difficult to sell in domestic markets. As most of the prune juice is purchased and consumed because of its laxative effects, there is considerable interest in identifying the constituents responsible for these effects, so that juice can be standardized with respect to laxative activity. This research has been underway for four years and has now been completed.

The conclusion drawn from the mass of evidence obtained by chromatography and also by chemical and biological assays, is that most of the laxative action of prune juice is due to the inorganic ions of magnesium and potassium. However, the effect of particular anions is real and complicating. In addition to the metallic ion laxation, it appears that some portion of the activity is due to a hydrophyllic organic moiety (as yet unidentified) found in prune extracts. This compound appears to be similar to methyl inositol, present in Jojoba oil, a laxative agent.

One of the findings under this project which may prove to have economic implication is that the natural sugars present do not complicate the laxative effect of prunes. It was found that the fermentable sugars could be eliminated by rapid fermentation with baker's yeast. No yeast-induced laxative effect was formed and the natural laxative properties were retained. It thus becomes possible to prepare palatable full-flavored, low-calorie prune juice which could be marketed as a frozen concentrate or as a bottle juice in the usual manner. Knowledge of the constituents which contribute to the laxative effect of prunes will make possible the preparation of controlled laxative juice.

Juice Quality of Concord Grapes: Cooperative studies are underway with horticulturists at the Washington State Experiment Station at Prosser, Washington on the effects of various cultural practices on the processing quality of juices from Pacific Northwest grown grapes. A color problem frequently exists in Concord grape juice because of the variability of sugar from year to year, while the color content remains more or less constant. Some of the color is colloidal.

and is lost during juicing, some is also lost during detartration, but these losses are constant. When a high Brix crop is obtained, the decreased amount of concentrating necessary to bring the juice to a specified sugar content results in a much less deeply colored concentrate. A pale, undesirable juice is thus obtained on reconstitution. Further, the anthocyanin pigments are heat sensitive and are partially destroyed by heat during processing, adding to this color problem.

Studies have shown that the color of Concord grape juice is due to at least 11 different pigments that behave like anthocyanins in paper chromatograms. The highest number of pigments of this type previously reported for the Labrusca sp. of grapes is 10. By means of paper chromatography it was determined that all eleven of these exist in raw grape skins as well as in the pigments that precipitate during detartration of the juice. Studies were also conducted on the blue pigments in the juice that are lost during detartration. Color was extracted from 70 pounds of argol lees from a commercial bulk detartration tank. This isolate was found to hydrolyze into four anthocyanin pigments that occur in grapes and grape juice. These four anthocyanins are the monoglycosides having the lowest R_f values when chromatogrammed with butanol-acetic acid-water solvent. Studies on these pigments are continuing.

Another pigment fraction differing from the above in its solubility in buffer solutions was isolated and purified. This preparation was free of the four monoglycosides and appeared to consist mainly of two different monoglycosides. Attempts are now underway to separate and identify these two pigments.

Studies on the effect of the acidity of the juice on color loss during detartration showed a slight increase in pigment loss when tartaric acid was added, but no appreciable loss when citric acid was added. The addition of sodium fluoride to the juice before detartration had no appreciable effect on color loss.

Investigations are underway at the Albany, California laboratory to determine if enough hydrogen peroxide results from ascorbic acid breakdown in fruit to oxidize these pigments. (It was previously reported in other laboratories that anthocyanins are readily oxidized by hydrogen peroxide.) An improved method of determining peroxide has been developed. The work has shown that both pH and amino acids contribute to anthocyanin breakdown. At high pH the heterocyclic ring is probably cleaved, forming a chalcone.

It has been demonstrated for the first time that anthocyanidins can be oxidized by atmospheric oxygen to the corresponding flavones. This not only supplies a possible explanation for the loss of color in processed pigmented fruits and vegetables but may also be of considerable significance in explaining the co-occurrence of anthocyanins and flavones in plant tissue. The precipitation and loss of anthocyanin pigments from grape juice may result, at least in part, from exposure to atmospheric oxygen in the bulk tanks used for storage and detartration.

of the juice.

Effect of Microbial Flora on Processing: Fundamental studies on microbial flora within the tissues of fruit and their effect on processing and preservation, as a basis for development of products of superior quality are being conducted under P.L. 480 in the department of food technology of the Ministry of Agriculture in Rehobot, Israel. The objective of these investigations is to determine the role of microorganisms in conventional processes for preservation such as brining, fermentation and preprocessing storage.

Studies of the bacterial content of grapes, apples and melons were conducted and were compared to tomatoes and cucumbers. It was found that the content differed according to origin of the raw material. Storage of surface sterilized fruit under anaerobic conditions appeared to foster multiplication of bacteria below the fruit surface.

In the early stages of this research emphasis has been placed on studies of citrus fruits. Shamouti oranges, Baladi oranges, and Marsh Seedless grapefruit have been studied along with the vegetables, tomato and cucumber. The results of these researches are being reported to the appropriate advisory committees.

Canned Concentrated Peach and Apricot Purees: A P.L. 480 grant has been executed with the Experiment Station for Food-Preserving Industries, Parma, Italy for a fundamental study of the effects of temperature and temperature variations encountered in transportation and distribution as a basis for improving processing conditions that will result in best quality retention.

In the early stages of this research program emphasis has been placed on a complete literature search; and on the refinement of methods for analysis of amino acids, vitamins and volatile constituents. The development of objective tests to measure quality changes is now underway.

Red Sour Cherry Composition and Texture. Additional information has been developed at EU on the relation of post-harvest treatment to the texture and drained weight of processed cherries. Studies of this relationship are important in view of the development of mechanical harvesting and water hauling procedures. It was previously reported that the usual methods of harvesting and handling cherries result in bruising and several hours delay at warm temperatures and that this results in a higher drained weight and firmer texture of the canned or frozen product. Microscopic examination of unbruised and bruised-aged cherries showed that the latter had thicker and more rigid cell walls. Thus the increase in drained weight is due in part to a more rigid internal structure of the individual cherry.

Respiration of Red Sour Cherries. It is important from the standpoint of optimum quality and scald prevention to determine whether or not red sour cherries pass through a "climacteric" as they mature.

Both the oxygen uptake and carbon dioxide output were determined at EU on cherry fruits from the "pea" stage to harvest maturity. Total respiration, both O_2 and CO_2 started out at a high level and continuously decreased over a period of several weeks, reaching a low steady level just prior to maturity, and continuing through to the overripe stage. There was no evidence of any respiration rise or "climacteric" as the fruit matured. This means that red sour cherries do not have to be harvested at a critical stage to achieve maximum quality but may be harvested over a relatively long period with very little physiological change. Also it indicated that there is probably no critical relationship between maturity and susceptibility to scald.

Plans: It is planned to extend the studies that have been underway at WU on the enzymatic browning of frozen peaches to other frozen fruit samples that show similar darkening.

As mentioned above research on new volatile flavor constituents of strawberries has been completed and emphasis is being placed on other flavor problems.

In the studies on chemistry of sulfur dioxide in dried fruit, model systems will now be used for developing procedures for isolation and identification of reaction products of sugar and SO_2 at various pH values as well as the degradation products formed when these are stored at high temperatures. Consideration is also being given to the use of radioisotopes to assist in the isolation and identification of the reaction products.

Investigations on the physiological factors in processed prunes has been satisfactorily completed with the confirmation that most of the laxative action of prune juice is due to the inorganic ions of magnesium and potassium, complicated by organic compounds present in trace amounts, such as methylated inositol derivatives.

Research on the juice quality of Concord grapes underway in Prosser, Washington, and Albany, California is being continued with emphasis on basic studies of anthocyanins and the mechanism of their breakdown.

The research which is being conducted in Israel and Italy under P.L.480 will be continued along the lines reported above. The above research at EU will be continued at the present level.

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2. CHEMICAL ATTRACTANTS FOR DROSOPHILA

WU

Problem: Drosophila (vinegar fly) infestations are a serious problem for many fruit processors including canners, dehydrators and vintners. In some cases products are judged to be unfit for human consumption due to contamination by Drosophila, and this results in a loss for the processor and the grower.

Program: A program of research on naturally occurring substances that are attractants or repellents to Drosophila is underway at Albany, California, involving one Federal professional man-year per year. Materials concentrated or isolated during this work are being provided to entomologists in other USDA agencies for further testing and for incorporation into more effective baits or "super attractants" to be used in control of Drosophila in the field and in processing plants.

Progress: During the past year, about 1,000 samples have been tested for their attractiveness to Drosophila by the Entomology Research Division. These samples are being compared to a standard lure which has been used as an attractant for Drosophila. None of the samples has equalled the attractiveness of the standard lure but there is a wide variation between the different test samples themselves. This indicates that fermenting mixtures at certain stages may be more attractive than those at earlier or later stages of fermentation. It has been found that activated carbon is capable of absorbing the attractive volatile materials that are elaborated by a fermenting mixture.

In one experiment ten gallons of the mixture of yeast, sugar and water was fermented and the volatile products were swept by an air stream into a solution of 2,4-dinitrophenylhydrazine. The precipitated material appeared to contain at least 2 compounds. Steam distillation of a fermented mixture demonstrated an abundance of acetaldehyde. Acetaldehyde and other carbonyls present in the volatiles from fermenting mixtures may play some role in the attractiveness of these mixtures for Drosophila. A gas chromatography apparatus has been constructed to aid in the separation and identification of compounds present in attractant mixtures.

Plans: In the early stages of this work emphasis has been placed on the preparation of fermentation mixtures and rough fractionation of these mixtures for testing. It is planned now to screen specific compounds or classes of compounds for attractiveness or repellency to Drosophila.

B. New and Improved Food Products and Processing Technology

3. IMPROVED DRIED FRUIT PRODUCTS

WU

Problem: Per capita consumption of dried fruits has decreased of recent years. This is thought to be due in part to the fact that dried fruits are subjected to conditions which result in more rapid deterioration of these products than is the case of fruit products preserved by other means. Information is needed about possible modifications of drying and dehydration processes which will yield better dried fruits of greater stability.

Program: A continuing long-term program on processing of dried fruit is carried on at Albany, California involving 2 professional Federal man-years per year and 1 industry sponsored man-year per year.

Progress: Studies on the effects of temperature and relative humidity on dried fruits reported last year have been continued during the past year.

It has been shown that color and weight changes take place more rapidly at higher temperatures. The greatest changes in weight were seen in apricots packed in saran-treated-cellophane bags; after 10 months at 70° F. and 40% relative humidity (R.H.), a 10% loss in weight was recorded. Color change was not affected by R. H. "Sugaring," recognized as a white encrustment of sugars on the surfaces of fruit pieces, occurred frequently on figs, prunes, and golden raisins at 35° and 50° F. but not at higher temperatures; some sugaring was seen in golden raisins in bags at 70° F. and 80% R.H. Taste tests on raisins, prunes, and figs revealed that significant changes in flavor took place in all three commodities at 90° F. in ten weeks. At 70° F. raisins had changed in flavor in 16 weeks but prunes and figs had not. The role of carotenoids in the off-flavor development in dried fruits is being investigated.

Dried fruit packed in transparent film bags has been exposed to light continuously for about 5 months. These illuminated samples are darkening in color at a more rapid rate than duplicate samples protected from light. Loss of SO₂ is more rapid in the illuminated samples. Taste tests, however, show no significant difference between the samples held in light or in dark.

Another phase of this program has been involved with the development and study of several kinds of antimycotic agents. High moisture prunes (35% H₂O) and figs (32-34% H₂O) were packed with several kinds of antimycotic agents. A dip of 2-3 minutes in a bath of 2% potassium sorbate and the standard epoxide treatment proved adequate to protect prunes and Mission figs from mold growth; some spoilage was detected in Calimyrna figs. Other agents were not effective.

Studies on the toxicity of the various antimycotic agents in general use by the dried fruit industry have also been initiated. It has also been reported that when high moisture dried fruits are treated with ethylene or propylene oxide, the epoxide reacts quickly to form hydroxyethyl hydroxpropyl sugars and small amounts of glycols. The substituted sugars are being isolated and characterized so that studies on these compounds can be undertaken. Studies are already underway on the effect of long-term feeding of diethylene glycol to rats. Increased excretion of oxalic acid by rats eating diethylene glycol diets is being studied.

Analytical methods to determine residues of methyl and ethyl formates are also being studied. Studies on the toxicity of these various chemical additives used by the dried fruit industries are being supported by the Dried Fruit Association of California.

Plans: Emphasis will be placed on the development of new and improved antimycotic agents and the determination of the toxicity of these agents to the consumer of dried fruits.

Publications: The Carotenoids of Cling Peaches. A. L. Curl. Food Research. 24 (4) 413-422 (1959).

The Carotenoids of Apricots. A. L. Curl. Food Research. 25 (2) 190-196 (1960).

Research for Better Quality in Dried Fruits -- Prunes. F. S. Nury, D. H. Taylor and J. E. Brekke. ARS 74-18 (May 1960).

Research for Better Quality in Dried Fruits -- Figs. N. S. Nury, D. H. Taylor and J. E. Brekke. ARS 74-16 (May 1960).

Research for Better Quality in Dried Fruits -- Apricots. F. S. Nury, D. H. Taylor and J. E. Brekke. ARS 74-19 (May 1960).

Preservative Effect of Some Antimicrobial Agents on High-Moisture Dried Fruits. F. S. Nury, M. W. Miller, and J. E. Brekke. Food Technology. 14 (2) 113-115 (February 1960).

4. DARKENING AND RANCIDITY OF TREE NUTS

WU

Problem: Shelled walnuts are convenient for a housewife to use but in this form the nuts tend to darken and turn rancid rather quickly. This is seriously limiting further expansion of this processing industry and because of higher costs the situation is resulting in decreased return to the growers. Knowledge of the chemical composition of shelled walnuts and the nature of the chemical mechanisms causing darkening and rancidity is required for the development of improved processing procedures that will result in more stable products.

Program: The continuing long-term program on basic and applied studies on the chemistry and preservation of shelled walnuts is being conducted in cooperation with the Diamond Walnut Growers, Inc., at Stockton, California, involving 1 Federal and 1 industry sponsored professional man-years per year.

Progress: Previous work has resulted in the development of practical processes for stabilizing shelled walnuts through the critical control of their moisture content by coating the kernels with antioxidants and sealing the treated kernels in bags of transparent film. In basic studies during the past year, amino and total nitrogen analyses have been obtained for samples of fresh and rancid walnut kernels with identical pre-storage histories. Studies of the rancid kernels indicated that losses in soluble free amino acids may be associated with measured losses in soluble nitrogen. Both qualitative and quantitative differences were observed for the amino acid patterns of these extracts. Relative to glutamic acid taken as unity, the extract of rancid kernels contained smaller amounts of arginine, lysine, aspartic acid, glutamine, leucine-isoleucine, and gamma-amino butyric acid. Filter paper chromatography technique was improved to where the R_f values may now be determined on two directional chromatograms with a precision of better than 2%, representing a 100% improvement over previous small scale procedures.

Thirty-four ninhydrin-positive constituents have been detected. About half of these constituents represent the free amino acids whose tentative identities had been established previously using filter paper chromatography techniques. Adequate amounts of the free amino acids are now available to permit their isolation, purification, and unequivocal identification.

The amino acid, alanine, was isolated in pure crystalline form and was characterized by precise measurement of its R_f value on two directional paper chromatograms and by the identify of its infrared spectrum with that of an authentic sample of alanine. Although this compound had been identified tentatively on paper chromatograms of walnut extracts, unequivocal identification was not possible using that method because of the unavailability of satisfactory confirmatory tests for use with paper chromatograms. Other fractions have been shown to contain essentially single components which are being purified further in preparation for infrared, elementary and chromatographic analyses.

Studies have been initiated for the determination of the fatty acid constituents in walnut oil. Palmitic, stearic, oleic, linoleic, and linolenic acids have been characterized. No fatty acids containing less than 16 carbon atoms have been detected. An unknown slow moving component has been observed and remains to be identified.

A new investigation has been initiated to determine the validity of the premise (suggested by prior experiments) that peroxide values oscillate two or more times during the development of rancidity in walnut kernels held at low moisture levels (2.5 to 3.5% moisture).

During the first 60 days of the experiment, a primary rise and leveling off of peroxide values has been observed for kernels held in the dark at 85° F.

In technological studies, exploratory tests were conducted on the belt-trough drying of shelled walnuts treated by the Armstrong method. The most effective drying operation was one in which an air inlet temperature of 180° F. was employed for 25 minutes, reducing the moisture content of the kernels from 17% to 6%, followed by a period of 30 minutes at 210° F. which reduced the moisture content of the kernel to 3.5%. Total drying time was 55 minutes. The belt-trough dryer was also used to dry in-shell walnuts. Kernel moistures were reduced from 4.4% to an optimum final moisture level of 3.5% after 17 minutes of drying at 200° F. and 8 days of in-shell equilibration. The usefulness of the belt-trough dryer for the rapid drying of walnuts has thus been demonstrated. This improves the quality of nut meats obtained by the Armstrong process and will help speed the commercial adoption of moisture adjustment as a means of improving the storage stability of in-shell walnuts.

Plans: Chemical and technological investigations will be continued to elucidate the chemical mechanisms responsible for darkening and rancidity as a basis for the development of new and improved methods of processing the stabilized walnut and other tree nuts.

5. CONCENTRATED FRUIT PRODUCTS

WU, EU

Problem: Mounting transportation, warehousing and handling costs are emphasizing the need for high quality concentrated liquid and solid form fruit products. Cheaper continuous processes with improved recovery retention and restoration of flavors must be developed to overcome these mounting costs.

Program: A continuing program of applied research is being conducted at WU on the development of concentrated liquid and solid form fruit products, involving 4 professional Federal man-years per year.

A continuing program at EU is in cooperation with commercial processors and equipment manufacturers, and involves about one professional Federal man-year annually. A contract with the Maryland Agricultural Experiment Station, College Park, Maryland, involving a total expenditure of \$17,411, studies initiated in 1958 and scheduled for completion in 1960, is concerned with the utilization of fruits and dairy products by providing information on the technology of using concentrated fruit juices and essences in ice cream.

Progress: Foam-Mat Drying of Fruit: Methods for making fruit and vegetable juice powders have been under study for several years at WU. Vacuum-puff drying and spray-drying have both been studied extensively. A recent development is foam-mat drying, first reported on tomato juice

last year. Foam-mat drying appears to offer advantages over other available methods and is being studied intensively with a view to putting it on a practical production basis.

In the original trials of foam-mat drying, the foams were spread on a Teflon or Mylar-coated belt in an 1/8-inch layer and conveyed through a warm air stream. Most foods required about 60 minutes in 160° F. air to dry to 2% moisture. Under these conditions air velocity and humidity had an appreciable effect on the time required. The limit of the process was the transport of water within the product to the free surface at which it could evaporate. Therefore, steps were taken to reduce the mean distance to the evaporative surfaces.

The foam was next extruded in 1/16" to 1/8" diameter spaghetti-like strips onto the belt. Drying rate was augmented by heaters under the plate supporting the belt. These changes reduced drying time to about 15 minutes. The dry product was difficult to remove from the belt in some cases and it was not possible to load the belt very heavily. Nevertheless this form of dryer was shown to be satisfactory as a sample maker and is still in use at the Albany, California laboratory. About a tenth of a pound of product per hour can be expected from each square foot of active belt surface used.

The successful production of high quality instantly dispersible tomato powders from foamed tomato juice concentrate and tomato paste has been extended to cover the drying of various fruit products. Orange, grape, and pineapple concentrates; apricot, prune, and apple purees; and various other liquid-form fruit-containing mixtures have been dried by this method. Foam stabilizers used have included solubilized soya protein, albumin, sucrose, fatty acid esters and glycerol mono-stearates. The most versatile stabilizer, glycerol monostearate (GMS) is particularly dependent on proper dispersion. Several effective methods of dispersion have been found. If one part of GMS is added to nine parts of 170° F. water and the mixture is violently blended for a few seconds, a stiff emulsion is formed. This emulsion is kept at 120-130° F. It remains dispersible for several days. The emulsion then can be added to the cold foods just before whipping to ensure a stable foam. Another method of GMS dispersion involves warming the food to 170° F, mixing in the solid GMS in the absence of air and cooling the mixture to room temperature. Foams can then be produced by whipping this mixture or dilutions of this mixture with the original food in the usual way. For most products, 1% stabilizer on the dry basis is enough. If the liquid has a low consistency and especially if it contains no fine solids, relatively more stabilizer is needed.

A new development in foam-mat drying is called the "crater" technique. This involves extruding a thin layer of foam onto a perforated metal sheet. When the sheet is passed over an air jet, this foamed layer

is pierced but not blown off. When heated air is forced through the sheet from the clean side, the foam is rapidly dried because of its extended surface in the direction of air movement. By this new crater technique the product containing 2% moisture can be doctored off the trays and packed and the trays reused without cleaning.

Dehydrocanning and Dehydrofreezing of Fruits: The processes of dehydrocanning and dehydrofreezing were conceived several years ago and are finding broad acceptance by the food processing industry. The work on these processes now under way at WU consists mainly in cooperating with commercial processors in putting up experimental or trial packs of a few hundred cases. These trial packs provide the processors with opportunity to see the whole operation in his plant and permit WU scientists to study larger-than-laboratory-scale processes.

Some pilot-scale studies have been conducted during the past year. These studies have yielded new information on processing conditions and operations required to produce dehydrofrozen apples. In the study, special effort was made to determine treatments that will permit use of air at normal ambient humidity in the drying operation. Earlier work had indicated that high humidity drying was necessary. Results of these pilot-scale tests show that good quality dehydrofrozen apples can be produced without the use of high humidity air if processing conditions are properly selected. It is now apparent that various types of drying previously considered unsuitable for use in producing dehydrofrozen apples can be successfully employed. A range of suitable processing conditions was established for apples of three different varieties, three different piece sizes, and different maturities. Information on the effects of wide variations in sulfuring treatment was also obtained to meet different needs in different plants. In addition, processing conditions were established for dehydrofrozen apples that do not contain sulfur dioxide, since it is felt that unsulfured fruits have great potential in America's export market.

Fruit Essences and Concentrates: Studies have continued on the use of fruit essences and full flavor concentrates as flavor ingredients in ice cream, sherbets and ice milks. Consumer acceptance studies in general confirm the results obtained by the professional judging panel. It has been established that the addition of fruit concentrates does not affect protein stability in these products and that the enhanced flavor in the experimental ice creams and sherbets is retained throughout the two-month storage period required for commercial distribution of the products. Studies will be extended to variegated ice creams, ice milk and ices.

Fruit Juice Powders: One thousand pound lots each of apple juice powder and grape juice powder with restored essence have been prepared at EU for the Quartermaster Corps for field testing.

A market test on full flavor superconcentrated apple juice has recently been conducted in Fort Wayne, Indiana, by the AMS in cooperation with EU, Wyndmoor, Pennsylvania, and the Michigan State Apple Commission. The product was made in a commercial plant by the EU process with an EU engineer at the site as consultant. During the entire test, including the 6-week period after termination of advertising, the sales of concentrate were more than 3 times as great as those of all brands of bottled and canned single strength apple juice combined. During the 6-week period after the advertising program the average sale of concentrate was 1-1/2 cases per day per store, equivalent to 3 cases per day per store of single strength canned juice.

During the test there was no significant drop in sales of any type of single strength juice, indicating that the concentrate is tapping a consumer market not reached by the single strength juice.

Publication by AMS of the favorable test market results should stimulate commercial adoption of the process for apple juice concentrate for beverage purposes.

Successful tests on the grape and apple powders by the Quartermaster Corps should interest manufacturers in that process.

Plans: Engineering studies at WU on foam-mat drying will be continued and supplemented by basic flavor studies aimed at obtaining foam-mat dry powders with fresh fruit flavor.

No definite experimental work on dehydrocanning and dehydrofreezing is planned at present at WU. It is planned however to give continuing active support to commercial ventures in dehydrofreezing. Some experimental work may conceivably be needed to fulfill requests by the industry, especially at an engineering level. The very rapid growth of interest in this process, however, indicates that its commercial acceptance is assured.

Cooperation will be continued with industrial processors and equipment manufacturers by EU to expedite commercialization of products and processes developed in the course of the pilot plant research. Future work is planned to prepare by this same basic process, "dry essences" (concentrated fruit essences locked into sugar mixture) for restoring aroma and flavor to dehydrated fruit products. Work is also planned on the production of instantly rehydrating fruit pieces by a new method developed for potato, carrot and vegetable pieces.

Publications: A New "Crater" Technique in Foam-mat Drying. CA-74-7, April 1960.

A Progress Report on Foam-mat Drying. Food Processing, (June 1960).

Technique for Improving Instant. A. I. Morgan, Jr., L. F. Ginnette, J. M. Randall and R. P. Graham. Food Engineering, (Sept. 1959).

Making Berry Juices and Concentrates for Use in Preserves, Juices, Syrups. J. D. Ponting, D. W. Sanshuck and J. E. Brekke. Western Ed., Canner/Packer 128 (9): 19 (September 1959).

Solid Flavoring Composition and Method of Producing the Same. T. H. Schultz, U. S. Patent No. 2,919,989. (Jan. 5, 1960).

Process for Preparing A Solid Flavoring Composition. B. Makower and T. H. Schultz. U. S. Patent No. 2,899,313 (Aug. 11, 1959).

Dehydration of Cherries. M. J. Powers, N. J. Downes. U. S. Patent No. 2,899,319 (Aug. 11, 1959).

Process for Preparing A Solid Flavoring Composition. K. P. Dimick and B. Makower. U. S. Patent No. 2,904,440 (Sept. 15, 1959).

Spray Drying Apparatus. M. E. Lazar and A. H. Brown. U. S. Patent No. 2,911,036.

6. DETERIORATION DURING PROCESSING

EU

Problem: Processors of fruits and tree nuts frequently encounter serious deterioration in their raw materials and in the processed products before, during, and after processing. These undesirable changes may be due to chemical, enzymatic, or microbial activity. Information is needed on ways of preventing deterioration through improved processes, equipment, or microbial inhibitors.

Program: A continuing long-term basic and applied research program conducted at EU, involving 1 professional Federal man-year annually.

At WU a long-term research program on microbial deterioration of peaches and other fruits is underway in cooperation with the Agricultural Marketing Service and Washington State College involving 1 professional Federal man-year per year. The deterioration of brined cherries involved two professional Federal man years.

Progress: Preservation of Cider. A new and improved method of measuring the sorbic acid content of apple cider has been developed at EU which is more rapid and more accurate than the standard method. The standard method involves the distillation of sorbic acid from cider under conditions which favor the formation of hydroxy-methyl-furfural (HMF). This compound interferes with the spectrophotometric determination of sorbic acid and introduces a large and uncontrollable error in the determination. The new method involves the direct determination

on a diluted sample of cider and avoids the formation of HMF. Fructose and sucrose, the principal sugars in cider, readily form HMF when heated in the presence of citric, malic, or mineral acids. The new method should be useful with other fruit juices and fruit products.

Rhizopus Rot in Freestone Peaches. Studies on the problem of rhizopus rot in freestone peaches have been completed. These were conducted cooperatively with plant pathologists of the Agricultural Marketing Service and with commercial growers and processors. Several aspects of the rhizopus rot problem were investigated. Contrary to common belief, airborne spores and contaminated field lugs were not found to be important sources of infection. The vinegar gnat or pomace fly (Drosophila sp.) was shown to act as a vector for the organism and to be an important source of infection of the freshly harvested fruit. It is probable that this fly is responsible when decay becomes excessive. Preliminary studies with entomologists in control of Drosophila in peach orchards showed that suitable methods were not immediately available.

Methods for treating fruit to control the decay were investigated. While some fungicide treatments were effective in reducing decay under carefully controlled experimental conditions, none gave effective control under commercial conditions. Preharvest treatment with fungicides were ineffective because they failed to protect areas injured during harvest. Post harvest treatments with fungicides were also ineffective because the fungus probably becomes established in the fruit tissues in the period between harvest and treatment.

Cold storage of peaches at 31° F. for two weeks before ripening substantially reduced the amount of decay during ripening. This control was found to be due to a cold-induced shock phase which inhibits the growth of fungus for 48-72 hours after returning the fruit to ripening temperatures. This finding has introduced a new concept in the behavior of this pathogen that may find application in the control of other plant diseases. While this treatment is not ideal, it has proven effective under commercial conditions. Preripening cold storage was used as a decay control measure on about 12,000 tons of peaches harvested for processing in the Pacific Northwest in 1959. It is expected that a higher percentage will be so treated in coming seasons.

Brined Cherry Deterioration. The softening and breakdown of sweet cherries during brine-curing is being studied from the standpoint of enzymatically catalyzed changes as well as changes that apparently take place in the absence of enzymes.

It has been shown that softening and disintegration of cherries can be brought about by adding commercial pectinolytic and/or cellulolytic enzymes to the curing brine. Nacconal, CaCl_2 and Scuppernong grape

leaves have been found to inhibit these enzymes, however, it has not been shown conclusively as yet that enzymes are responsible for softening of cherries during commercial brining nor how such enzymes are introduced. Significant variations in texture can be brought about by varying the composition of the brine. About 80 different brine formulations have been tested this past brining season to determine their effect on texture. A small spring-loaded puncture meter is being used for objective measurement of texture.

Texture measurements have shown that the formulation of the brine does affect the texture of the cherries and rather sharp limits of acceptability have been shown for the composition of a brine made by mixing SO_2 and lime. Brines composed of sodium bisulfite, calcium chloride and hydrochloric acid are equally satisfactory and probably are better for cherries which show abnormal reactions in the brine cure process.

Yeasts were isolated from cherries and it was found that of 10 strains of "black yeast" tested, only one regularly caused necroses to occur. These gradually engulfed the whole fruit. Such fruit was found to be rich in polygalacturonase and when put into brines with cherries, the latter softened slowly. Polygalacturonase appeared in the brine and showed undiminished activity after five months. Use of CaCl_2 to prevent softening of cherries is being investigated further this year.

Ultra-centrifuge studies of pectin prepared from firm and soft cherries has shown differences of a rather anomalous nature. A fast moving component presumably of relatively high molecular weight appears in cherries that have been softened by pectinolytic enzymes. This feature does not appear in the pectin preparation from firm brined cherries.

Statistical analysis of the data on the use of the simple puncture meter mentioned above has revealed that the standard deviation of a set of data on a given sample affords an important clue for predicting what might be expected in subsequent measurement on a given lot of cherries. Those being cured in brines known to cause softening show a higher standard deviation than those in brines which will give satisfactorily firm cherries. The mean value of the respective sets of data may not be significantly different in the early stages of the curing process, but the standard deviations of those beginning to soften will be significantly higher. This statistical technique offers a possible method of predicting the onset of softening of cherries. This, combined with qualitative or semi-quantitative enzyme tests, may provide the basis for anticipating trouble in a batch of brine cherries and for instituting remedial action.

Plans: The work at WU on rhizopus rot of Freestone peaches has been successfully completed and no further work in this area is planned for the immediate future. Studies will be continued on the various microbial species collected during the past year from softened brined cherries.

Work on the preservation of cider at EU will be continued along the same lines and at the same level.

Publications: Ripening Conditions for Northwest Frees (Freestone Peaches). A. M. Neubert. Canner/Packer 128 (8): 34-36 (August 1959).

B. New and Improved Food Products and Processing Technology

7. TIME-TEMPERATURE TOLERANCE OF FROZEN FRUITS

WU

Problem: Frozen fruit products will deteriorate in quality if processing procedures have been inadequate or if proper conditions of temperature are not maintained. Information on freezing rates and special problems encountered with bulk packages is needed to assist the industry in providing uniformly high quality products to consumers.

Program: A continuing long-term program on time-temperature tolerance on frozen fruits and fruit products is carried on involving 3 professional Federal man-years per year.

Progress: Intensive research on the effect on quality of the processing and temperature history of frozen foods has yielded information that is being used by all segments of the industry. Improved processing procedures based on these findings have been very widely adopted. The rate at which product quality declines at various temperatures has been measured; and the permissible exposure of frozen foods to above 0° F. temperatures without excessive quality changes has been determined.

Studies on bulk pack frozen strawberries in 30-pound cans held at various temperatures has clearly shown that the quality of fruit held at elevated

temperatures of around 20° F. for 6 - 8 months is materially reduced when compared to control samples held at 0° F. The results on strawberries have repeatedly shown that color is the most important factor governing the shelf life of preserves. However, extensive processing trials have shown that processing time and temperature affect preserve quality far more than conditions of storage of the frozen strawberries or the finished preserves.

Results on frozen bulk-pack blackberries and raspberries held at temperatures from -20° to +20° F. has shown that these fruits are much more stable than frozen strawberries. Color and flavor was relatively unchanged after two years, one year, and six months at 0°, 10°, and 20° F., respectively, in blackberries; and two years, nine months, and three months at 0°, 10°, and 20° F., respectively in raspberries. At 20° F. color and flavor changes in frozen strawberries are easily noticeable after one month.

A pallet freezing survey in eleven commercial strawberry freezing plants has been completed and the results analyzed with respect to quality changes caused by the various cooling rates encountered. Quality loss was determined by graphical integration according to the method of Van Arsdel and Guadagni. The system was constructed from data on rates of flavor and color change in sliced sugared strawberries held at steady temperatures ranging from 70° to 0° F. The slowest cooling rate encountered in this survey caused a quality loss equal to that which occurs at 0° F. after two years; at 10° F. after four months; and at 20° F. after three weeks. In terms of 0° F. storage, this means that the berries were the equivalent of two years old before they reached 0° F. The best or fastest cooling rate encountered in the survey caused a quality loss equal to that which would occur during three months holding at 0° F. These results show that maintenance of low temperatures during transportation, warehousing, distribution and retailing will not ensure high quality frozen strawberries so long as the pallet freezing procedures now in common use are continued. Excessive quality deterioration occurring during pallet freezing undoubtedly is sufficient to reduce consumer acceptance of the product.

Plans: The work on time-temperature tolerance of frozen fruits and fruit products will be continued at the same level as at present.

Publications: Time-Temperature Tolerance of Frozen Foods. XX. Boysenberries. D. G. Guadagni, K. M. Eremia, S. H. Kelly, and Jean Harris. Food Technology 14 (3): 148-150 (March 1960).

Protect Frozen Foods from Temperature Damage. ARS-74-9 Rev., Sept. 1959, WURDD, USDA, Albany, California.

Research for Better Quality in Frozen Foods. ARS-74-13, Aug. 1959, WURDD, USDA, Albany, California.

Taking Product Temperatures in Frozen Food Cases. ARS-74-14, Sept. 1959, WJRDD, USDA, Albany, California.

8. IMPROVED FRUIT AND NUT PRODUCTS AND PROCESSES

WU

Problem: The utilization of many fruit and nut products has failed to achieve what is considered a normal rate of increase. Per capita consumption of some of these products has in fact steadily decreased for the past few decades. If a greater share of the consumer's dollars is to find its way to fruit and nut growers and processors, products of greater appeal must be offered to the consumer. New enticing products must be formulated, the quality and stability of all products must be improved, and lowered costs must be realized by more efficient and economical procedures.

Program: The continuing long-term program of research at WU on processing methods and products of fruits and nuts is being conducted with substantial cooperation from the Washington Experiment Stations, and in cooperation with various industry committees and advisory boards. Twelve professional Federal man-years per year are involved in this program of research.

The continuing long-term program of research on improved products from fruits at EU is being conducted presently by contract with the Maryland Agricultural Experimental Station, College Park, Maryland, by studying the relationship between the constituents of apples and textural characteristics of their processed products.

Progress: Moisture Barrier for Raisins: Laboratory-scale studies on a method for stabilizing raisins against change in moisture content have been completed. The method consists of dusting raisins with soluble starch, then coating them with beeswax or a mixture of beeswax and edible vegetable oil. Raisins (15-16% moisture) thus treated retain their moisture so well when incorporated in a dry cereal product that after 90 days they are still soft and edible. Untreated raisins become hard and inedible in this length of time. To further illustrate the stability of raisins treated as above, they were held along with untreated control samples in a chamber at 70° F. and 20% relative humidity (R. H.). After two months the coated raisins were soft and contained 12% moisture. The untreated controls lost moisture so rapidly that they were down to 12% moisture in a week and at the end of two months were hard and contained only 6.5% moisture. It is estimated that the shelf life of cereal flake products containing beeswax coated raisins is extended by a factor of five or more over those products containing regular raisins. Cereal companies have been striving to double the shelf life of cereal flake products containing raisins or other dried fruit. The process that has been developed has surpassed this goal. The coating process may be applicable to other dried fruits in either whole or chopped form and offers an expanded outlook for all types of dried fruits.

Pilot-plant and commercial scale development is being carried on cooperatively under Memoranda of Understanding with the California Raisin Advisory Board and the Bonner Packing Company, both of Fresno, California. Equipment for the starch-dusting and wax-coating of raisins was built and installed in the plant of the industry cooperator in Fresno, and trial runs were conducted. The coated raisins from these experiments were found to have excessive amounts of wax (up to 5% of the weight of the raisins) on the surface. An improved continuous process has since been developed by personnel of WU's Engineering and Development Laboratory. This process yields wax-coated raisins with 1-2% of wax adhering in a thin unbroken film. This amount of wax pick-up is within the practical limits suggested by cereal manufacturers who use raisins in raisin bran flakes. Coated raisins are being evaluated by principal users.

Processing of Prunes: Contract studies at the University of California, Davis, California on preliminary steps in processing of prunes and the factors involved in microbial spoilage of dried prunes has been completed. It has been found that the quality of dried prunes is influenced more by the handling of the raw material than that of almost any other processed fruit. The maturity at harvest, method of harvest, all have pronounced effects on the quality of dehydrated prunes. Maturity at harvest is an especially important factor since it is a fairly common practice to allow prunes to shrivel or partially dehydrate on the tree or even on the ground under the tree before they are harvested. When prunes are permitted to stay on the tree too long or are not picked up from under the trees promptly, gas pockets form, spoilage results from mold and yeast growth, and the color of flesh darkens.

Mechanical harvesting, of increasing interest to the prune industry, was evaluated to determine whether procedures would have to be modified in order to ensure a processed product of quality suitable for the prune trade. Results obtained from the harvesting studies, including correlation of flesh firmness with processed fruit quality, have made possible better schedules for harvesting and have shown that mechanical harvesting can provide fruit of at least as good processing quality as can comparably supervised hand harvesting. These findings have been widely disseminated to the prune industry through conferences with various dried fruit associations and grower groups and the recommended practices are already in use by the industry.

Studies of microbial spoilage of processed dried fruit showed the microorganisms to be yeast and molds. Sixty-two yeasts and 124 molds were found and classified.

Since in heavy crop years available dehydration capacity is usually insufficient to allow the processing of the crop as rapidly as it is harvested, cool storage prior to dehydration was investigated as a method for reducing microbial spoilage. Holding at reduced temperatures -- even as low as 32° F. -- was shown to be of only limited

value since microbial spoilage of the raw fruit was found to occur after only 10 days.

An observation in this study was that the subjective quality grading system now used for dried fruit makes it difficult to detect or measure variations that relate to those observed in fresh fruit. Organoleptic tests revealed differences which correlated more closely with information gained from fresh fruit analysis than did grade classification of the same sample. The need for the development of more objective methods of determining processing quality of the fruit was clearly demonstrated.

Development of Continuous Juice Press. The apple juice industry has an urgent need for a practical sanitary unit to replace the unsatisfactory rack and cloth press in general use. Many attempts have been made to develop a better press, but without success. During the past two years several new commercial juice recovery systems were tried in various plants around the country but none has found general acceptance in the industry. The limited information available on the results of these plant-scale tests indicates a competitive position for our own development in this field. During the past processing season, 60 tons of juice apples in 3 lots from Hood River, Oregon, representing early, mid-season and late season fruit, were processed in our machine. Optimum pressing conditions were established. It was found that the capacity in tons per hour was $2\frac{1}{2}$, $2\frac{1}{4}$, and $1\frac{1}{2}$ for early season, midseason and late season fruit, respectively. The gross yield was constant for three lots of fruit and ran from approximately 68 to 70%. The machine was operated at a drum speed of $1\frac{1}{2}$ rpm.

It was found, however, that the capacity of the machine was greatly increased by operating at a lower gross yield of about 60%. Such a yield may be adequate if the pomace is repressed in a second machine.

The in-plant tests indicate that the internal drum press operates well from a mechanical standpoint but produces a juice that is not quite as clear as juice from a good rack and cloth press operation. The gross yield is also somewhat lower than for a rack and cloth press. The development as it stands now is competitive only if much labor is involved in a rack and cloth operation, and if apples are plentiful and therefore cheap.

The cost of operation alone does not, however, tell the whole story. Because of its all-metal construction with all contact parts of stainless steel, the continuous press does not contaminate the juice as does a rack and cloth press. In the long run this factor may become far more important than any small difference in production costs.

Since mechanical simplicity is an important factor in commercial type processing equipment, work is now underway to simplify the general arrangement of the press and to more nearly approximate the design

for a commercial-type machine. Experimental components such as the hydraulic system for adjustment of pinch opening, multiple juice collecting channels, etc. are being replaced by simpler devices that are less versatile from the experimental standpoint but are more practical for commercial use.

Fouling of Heat Transfer Surfaces. This project has been completed. It was undertaken to obtain fundamental data relating to processing conditions and fouling rate of heat transfer surfaces in flash entry evaporators and to provide a rational basis for designing improved evaporators for fluid foods.

The factors affecting the fouling rate of evaporator surfaces have been identified as surface temperature, concentration of solids in the liquids, and vapor fraction accompanying the liquid. Mass velocity, linear velocity, heat flux and steam or liquid temperatures did not, in themselves, affect fouling rates except through their effects on the three prior factors. The effect of surface temperature on fouling rate could be interpreted in terms of the activation energy of the fouling reaction. For tomato products this energy is consistent with the activation energy of wet protein denaturation. Analysis of the wall deposits after evaporation of tomato, grape, and some synthetic mixtures also suggested that the fouling reaction involved proteins primarily, even when the protein concentration was extremely low.

These basic conclusions lead to several considerations in regard to the design and operation of the evaporators generally. Feed should be preheated to its boiling point at the pressure existing at the entry of the evaporator tube. This avoids the high surface temperature which would exist in a region of high resistance to heat transfer from the wall to the liquid. This high resistance is characteristic of the warming as distinguished from the boiling region.

Concentration must be effected by passing the liquid a number of times through the same or different tubes allowing the vapor to escape between successive passes. This conclusion arises from the fact that fouling increases as the vapor fraction increases. Fouling also

increases as concentration increases -- hence, for a large change in concentration per pass, fouling is likely to be severe.

A novel technique was developed during this research. In this technique the stainless steel evaporator tube was itself used as a resistance thermometer. Current flowed lengthwise in the tube while the voltage drops across short sections were measured by means of wires attached to a tube passing out through the steam jacket. When direct current flowed, the voltage drops were proportional to the temperature at the radial center of the tube wall. When audio frequency alternating current flowed, the voltage drops were proportional to the temperature near the outside surface of the metal wall. This effect arises from the decrease in inductive impedance with radius in an annular conductor. Simultaneous observation of these two temperatures in the same region made it possible to calculate the surface temperature and heat flux in that region. This technique seems to offer great promise for research in heat transfer generally.

Some difficulty arose in the operation of the steam injectors used with the flash entry evaporators and this was systematically investigated. Exact design criteria and operating instructions were developed for use of steam injectors for any purpose. The effects of various conditions and designs were observed by means of entry and exit fluid properties. In addition a glass model was built and high speed motion pictures were taken of its operation. This resulted in data on instability and vibrations. These data were received with great interest by a variety of industries interested in adopting steam injection heating. The factors of heat flux, temperature difference, and vapor fraction have been correlated for the nucleate boiling of water flowing down a steel tube. These are the crucial interrelationships for the design of any vapor generator of the forced circulation type. These data were a necessary prelude for the study of fouling and may prove to be of great economic value because this information will be useful in the design of nuclear boiling water reactors.

The results obtained in this project offer the first scientific basis for interpretation of fouling phenomena.

Canned Apple Slices and Sauce. A three-year contract study by EU with the University of Maryland has been completed. This study showed that the optimum quality for processing is different from the optimum quality for fresh market. Apples harvested for fresh market require further ripening and storage to give good quality canned slices or sauce. Several chemical and physical characteristics of apples were identified as useful guides to harvesting and storage practices that will provide maximum quality in the processed product.

A new five-year contract with the University of Maryland will extend this study with emphasis on the relationships between the water

insoluble constituents (pectin, cellulose, and lignin) and the texture of canned slices and consistency of sauce. Preliminary results to date indicate that softening of apples during storage is due to changes in the starch-pectin complex. Presumably a naturally occurring pectinase enzyme attacks the starch-pectin complex in post-harvest storage.

Plans: Engineering studies will be continued at WU on developing equipment for coating raisins. The applicability of this procedure will be evaluated on other fruit products.

Contract studies at the University of California, Davis, California on the processing of prunes have been completed and no further work is planned.

The continuous juice press is being modified to make it more practical for commercial use. This press will receive further evaluation during the next apple pressing season.

Fundamental data obtained on the fouling of heat transfer surfaces is being applied to the solution of specific practical problems encountered in various types of heat transfer operations.

Publications: Carob: A Possible New Ingredient. R. J. Binder and J. E. Brekke. Manufacturing Confectioner 40 (1): 25 (Jan. 1960).

Steam Injection Heating. A. I. Morgan, Jr., and R. A. Carlson. Ind. Eng. Chem. 52: 219 (1960).

Control Vacuum Evaporation by Temperature. P. W. Kilpatrick. Chem. Eng. 66 (3): 132 (Feb. 1959).

Vapor-Load Steam Ejectors to Control Vacuum. Paul W. Kilpatrick. Control Engin. 6 (8), 109 (1959).

Modern Food Processing. M. M. Boggs and C. L. Rasmussen. Food - the Yearbook of Agriculture 1959, U. S. Department of Agriculture, p. 418-33.

Coating of Raisins and Other Foods. G. G. Watters and J. E. Brekke. U. S. Patent No. 2,909,440 (Oct. 20, 1959).

Method for Preparing Unsulphured Dehydrated Fruit. M. E. Lazar and M. J. Powers. U. S. Patent No. 2,895,836 (July 21, 1959).

Study of Fruit and Vegetable Processing Waste Disposal Methods in the Eastern Region. W. W. Eckenfelder, Charles F. Woodward, John P. Lawler and Robert J. Spinna. Final report of RMA Contract No. 12-14-100-482(73), 99 pp. and 16 figures. Manhattan College, New York City, Sept. 1958.

9. FACTORS AFFECTING PROCESSING CHARACTERISTICS

EU

Problem: The suitability of new and improved varieties of fruits and tree nuts and the effect of cultural factors on the suitability for processing are problems constantly facing the processor.

Program: A continuing short-term study at EU in cooperation with Agricultural Engineering Research Division, involving about 1 Federal professional man-year. The work of WU is of a continuing nature and in cooperation with the Washington State Experiment Stations at Puyallup, Mount Vernon, Vancouver and Prosser and involves two professional Federal man years.

Progress: Quality of Mechanically Harvested Red Sour Cherries. Previous studies at EU on bruising showed that commercially harvested cherries are severely bruised. The pickers strip the fruit from the tree and accumulate large handfuls which causes further crushing of the fruit before it reaches the pail or lug. It was shown experimentally that dropping the fruit directly onto elastic netting or padded catching frames reduced bruising. In 1958 the first mechanical harvester was used on sour cherries by the Agricultural Engineering Division of USDA. By 1960, forty machines were in operation on sour cherries. Our studies have been confined to the effects of mechanical harvesting on the quality of cherries for processing. Results to date show clearly that mechanical harvesting, if done properly, causes about the same, or slightly less damage to cherries than by present hand picking. This new development will favor tank hauling of cherries from orchard to processing plant with the possibility of eliminating or greatly reducing scald.

Processing Studies on New and Improved Berry and Tree Fruit Varieties. Canning, freezing, and preserving studies on new and improved berry varieties have continued in the Fruit and Vegetable Products Laboratories at Prosser and Puyallup, Washington. These studies are being conducted in cooperation with horticulturists of the Experiment Stations in Puyallup, Mount Vernon, Vancouver, and Prosser. Having suitable processing methods for handling these berries is very important as most of the berries grown in the State of Washington are processed. For example, during recent years over 90% of the total production of strawberries, raspberries, and blackberries and more than two-thirds of the blueberry crop have been processed.

Work at the Prosser and Puyallup Laboratories was concerned with the chemical analysis and preparation of processed samples of soft fruits and berries in season. Studies at Prosser included the varieties and selections of apricots and freestone peaches under cultural trials at the Washington Irrigation Experiment Station. Processing trials were also continued on the canning quality of peaches grown under extremely high nitrogen fertilization.

Exploratory studies were continued on the canning quality of Bartlett pears from trees suffering from pear-decline. This disorder of unknown

etiology is seriously curtailing pear production in the Pacific Northwest and appears to be developing in California. Fruit from infected trees mixed with fruit from healthy trees may be responsible for color and flavor problems. Those from Bartlett trees suffering decline were higher in soluble solids and tannins than fruit from healthy trees, but ripened at about the same time. Twenty-six lots of pears from eight commercial orchards were analyzed and canned for later evaluation.

Three new apricot selections were found to be unsuitable for canning because of soft flesh. These seedlings had been selected as the most desirable on the basis of productivity and fresh fruit market quality from some 800 crosses.

Two of four promising new peach selections developed at the Experiment Station, Numbers 1194 and 766 and one new commercial variety, Giant Alberta, were found to have good quality when canned or frozen.

Continued study of the effect of nitrogen fertilization of Elberta peaches on the canning quality showed that excessive application, up to eight pounds of actual nitrogen per tree, had little, if any, effect on canning quality compared with applications of about 1 pound per tree.

In addition to the established varieties of strawberries, blueberries, blackberries, and raspberries, eleven new hybrid selections of strawberries and twenty new red raspberries were evaluated at Puyallup. A study on the effect of maturity and quality of frozen strawberries showed that there was definite quality loss in over-mature fruit. In quality comparisons of strawberry preserves the new variety, Cascade, was preferred because of better flavor and color. Northwest was not highly rated but a mixture of Puget Beauty and Northwest had a very pleasing flavor. Preserves made from Sumner, Puyallup and Washington raspberries were rated highest in a paired comparison test with a 20-member panel. Wilamette was rated intermediate and Canby lowest. Herbert was considered best of several new blueberry varieties for preserves because it had the desirable wild mountain huckleberry flavor esteemed in the Pacific Northwest.

Results of a preliminary study at Prosser on the use of raw fruit color in dark sweet cherries and Italian-type plums as a maturity index in harvesting for canning, were encouraging. Grade scores for color assigned to experimentally canned Bing and Lambert cherries by commercial processors were related to raw fruit pigment content. Color grades assigned demonstrated that good color included a wide range of harvest maturities but deeper color was considered necessary for the Bing variety than for Lambert. Because orchard infestation with mites prevented full maturity in the plum series, commercial scoring was not possible.

Plans: Work on the processing quality of mechanically harvested cherries will continue at about the same level at EU.

Processing studies on new and improved berry and tree fruit varieties will be continued by WU in cooperation with the Washington Experiment Stations at Prosser and Puyallup. No change in emphasis is contemplated.

Publications: Mechanizing the Harvest of Red Tart Cherries, J. H. Levin, H. P. Gason, S. L. Hadden and R. T. Whittenberger. Quarterly Bulletin, Michigan State University Agricultural Experiment Station, East Lansing, 42:4, May 1960, Article 42-60.

Display of Berry Varieties. E. R. Wolford and J. A. Sacklin. Western Washington Hort. Assn. Proceedings 50:78-80. 1960.

III. MARKETING RESEARCH

A. Market Potentials, Preferences and Development

1. PURCHASE AND DISTRIBUTION PATTERNS

MD

Problem: Knowledge of consumption patterns of deciduous fruits and tree nuts in schools and other outlets is essential for administration of public programs and for private and public efforts to broaden and improve the marketing of these commodities in fresh and processed form.

Program: This is a continuing program of marketing research using field studies and analyses on a national, regional or local basis. It involves less than one professional man-year annually and in some studies the use of private contractors for data collection and tabulation.

Progress: Seasonal fluctuation in consumer purchases of canned fruits. A study of household purchases from July 1958 to June 1959 of canned peaches, pears, fruit cocktail, and selected canned vegetables, showing purchases by region and family characteristics, was completed and publication issued. Findings showed the extent of seasonal variations in purchases. Per capita purchases of canned peaches, pears, and fruit cocktail for home use were high during winter and spring and low during summer months. Wide variations also were found as to percentage of households purchasing, frequency and size of purchase, by region and product. Although these canned foods are purchased by a large percentage of households, the bulk of purchasing is done by relatively few heavy buyers. The 10 to 20 percent of households with heaviest purchases accounted for approximately 70 percent of all sales through this outlet for canned fruits.

Plans: Limited findings concerning heavy, intermediate, and infrequent purchasers bear strong implications to the planning of industry market expansion activities. Basic data will be reexamined to obtain further information concerning family size, age and working status of housewife, and other characteristics of households in these respective purchasing categories.

Publications: Household Market for Canned Fruits and Vegetables. Kenneth E. Anderson and Russell L. Hawes. Agr. Marketing, August 1960.

The Household Market for Selected Canned Fruits and Vegetables. Kenneth E. Anderson and Russell L. Hawes. USDA Mar.Res.Rept.#427, Sept.'60.

2. MARKET POTENTIALS FOR NEW AND IMPROVED PRODUCTS

MD

Problem: Commercial firms are reluctant to adopt new or improved products which are important in expanding or maintaining markets, particularly where public patents are held, because of the high cost of introducing such products and the risks of failure and that competitors will take advantage of successful introductory work; research is needed to encourage commercial adoption by determining and publicizing the potentials for success.

Program: The program consists of product and market testing and economic analyses, conducted for the most part in cooperation with the four regional laboratories of the Agricultural Research Service. The continuity of the program depends largely on new product research and development of the utilization laboratories. Field studies are national, regional, or local depending on the nature of the particular problem being researched. Approximately 2 professional man-years annually are involved in this work at present.

Progress: Dehydrofrozen apple slices. As a result of preliminary investigations, it was determined that a full-scale study of the market potential in the baking industry for dehydrofrozen apple slices was feasible. A sample of retail bakeries (baking their own apple pies) has been ~~drawn~~ in Baltimore, Md., Philadelphia, Pa., and Washington, D. C. The sample provides a total of 168 bakeries to become potential cooperators in a product test of dehydrofrozen apples.

Market potential for superconcentrated (7-fold) apple juice. In cooperation with the Eastern Utilization Research Laboratory and the Michigan State Apple Commission, a market test of a new superconcentrated apple juice was conducted in Fort Wayne, Indiana. Early in May 1960, 23 supermarkets were stocked with the test product, "Johnny Apple Squeeze," and sales audits were taken for the new product and closely competing products for 10 weeks following the introduction. Preliminary analysis of sales data indicates that the product has a good chance of commercial success (see "Consumer Preferences" for follow-up of consumer survey on this product.)

Plans: A product test of dehydrofrozen apple slices will be undertaken if the cooperation of the apple industry can be obtained, particularly in processing and distributing the test product. Analyses of the data collected in the market test of a superconcentrated apple juice will continue and the study will terminate with the publication of a report.

3. DISCRIMINATION AND CONSUMER PREFERENCE

MD

Problem: Marketing agencies need to know why the consumer selects certain products over others, the reasons she purchases, when, how, and what she purchases, and her reactions to variations in quality or other factors in order to carry out an effective and efficient program of market development.

Program: The program is one of continuing marketing research involving national, regional, or local surveys among consumers, both household and industrial. The studies are conducted in cooperations with States experiment stations, agricultural producers, processors, and distributor groups, and involve about one professional Federal man-year annually.

Progress: Consumer preference for superconcentrated (7-fold) apple juice. In cooperation with the Eastern Utilization Research Laboratory and the Michigan State Apple Commission, a market test of a new superconcentrated apple juice was conducted in Fort Wayne, Indiana. (See writeup in market potential for superconcentrated

apple juice for details on the sales audit phase of the market test.) About a month after the four week promotional campaign, a consumer survey was conducted during July and early August among a probability sample of over 500 homemakers in Fort Wayne. Interviewers asked about such items as homemakers' awareness of the test product's availability, whether or not they had purchased it or made repeat purchases, overall reactions to the product, etc. Some information was also gathered about use of other apple products. Analyses of the consumer survey data are currently under way. It appears that the majority of homemakers who purchased the test product were pleased with it and were interested in making further purchases.

Plans: Analyses of the data collected in the consumer survey are being made and the study will terminate with publication of a report.

4. NEW AND IMPROVED MERCHANDISING METHODS

MD

Problem: A continuing need exists to encourage improvements in the retail merchandising of deciduous fruit and fruit products through better packaging, pricing, display and other measures that will attract shoppers and enhance their competitive position in the marketplace.

Program: The program is one of long-term marketing research involving field studies and analyses of merchandising methods on a national, regional, or local basis depending on the requirements of the problem being considered. In many instances work is undertaken in cooperation with food stores as well as agricultural groups. Less than one professional Federal man-year is required.

Progress: Sales effect of various types of consumer packages (MD, MQ, T&F) Analysis of data obtained in a controlled retail food store experiment in Minneapolis as to relative costs, quality maintenance, and sales effectiveness of various types of consumer packages for apples, pears, and grapes has been completed. Large apples, packaged 6 per unit sold about as well whether displayed in polyethylene bags, cellophane sleevewrapped trays or cellophane overwrapped trays, and the types of package had no visible effect on the keeping quality of apples whether displayed on refrigerated or nonrefrigerated racks.

Medium-size pears in units of 6 per package sold equally well whether displayed in cellophane sleevewrapped or cellophane overwrapped trays. The quality maintenance for each package type was about the same except when displayed on nonrefrigerated cases when scald was less noticeable on pears in overwrapped trays. Packaging in poly bags and cellophane sleevewrapped trays cost nearly a penny less per package than the 4.4 cents cost in overwrapped trays. Grape sales were 18 percent greater when offered packaged in home toter bags (open top paper bags with handle) than when displayed in overwrapped trays. Home toter bag was also found to be more economical and somewhat preferred for its ability to maintain quality. However, because the home toter bags were unsealed, and were only partially filled, some customers supplemented their purchases from surrounding packages which resulted in a loss estimated to be about 4 percent of sales. If home toter bags are to be used successfully, retailers should select bag sizes that will hold only the desired volume for a selected pricing unit.

Use by Food Retailers of Merchandising Aids Provided by Agricultural Groups.--A study is under way to evaluate the extent of use of food retailers of in-store promotional materials provided by agricultural groups and to determine the policy of retailers regarding use, and requirements for acceptance and characteristics desired in in-store promotional materials. Extent of use will be observed in a national sample of approximately 1,800 stores and interviews will be conducted with appropriate retail and wholesale trade merchandising officials in 10 major metropolitan areas.

Plans: Further research work is contemplated in the area of package evaluation depending upon the needs and requests of industry. Collection of data for the study of extent of use and factors influencing the use of in-store promotional materials is planned for the fall of 1960. Tabulation and analysis of the data are scheduled for completion by late spring 1961.

Publication: Displaying Fruit in Various Types of Packages and in Bulk--Costs and Effects on Quality and Sales.--Nick Havas, Peter L. Henderson, Chester E. Parsons, and Paul Schaffer, USDA-AMS 391, August 1960.

5. EVALUATION OF PROMOTIONAL PROGRAMS FOR DECIDUOUS FRUITS MD

Problem: Because of price-depressing seasonal surpluses and the declining consumption of a number of deciduous fruits and fruit products, many producer groups have turned to promotion in an effort to maintain and expand markets. These groups need information on (1) the most appropriate procedures to be used in developing and carrying out promotions, and (2) the relative effectiveness of alternative types of promotional activity to assist them in planning, initiating, or redirecting promotional activities that will achieve maximum impact on consumer demand.

Program: This is a continuing long-term program of marketing research conducted on a national, regional, or local scale, and in cooperation with State Departments of Agriculture, colleges, and agricultural producers' promotional groups. It involves less than one professional man-year annually and some contract funds.

Progress: Advertising and promotional procedures.--Research has been initiated under contract with Northwestern University to develop a manual of basic advertising and promotional procedures which will be of assistance to agricultural producer groups in planning and carrying out promotional programs. The specific objective is to develop basic information relative to (1) the organizational structure of advertisers and the responsibilities and functions of each department; (2) the influence of such factors as the size of advertising budget and the specific objective or emphasis of the promotional program on types of organizational structure; (3) the advertiser-agency relationships and responsibilities in carrying out promotional programs; and (4) how advertising and public relation expenditures are allocated among the different services provided by the advertising agencies. The field phase of this work is now under way.

Evaluation of promotional program for apples. A study to appraise the effectiveness of a special promotional campaign sponsored by the Washington State Apple Commission has been completed. Specifically, the objectives were to evaluate (1) the general effectiveness of a promotional program, and (2) the relative effectiveness of different promotional themes for apples.

Compared to similar periods of no promotion, sales of Washington-grown apples per store were 32 percent greater for the "apple use" promotional theme and 21 percent greater for the "general health" promotional theme. Sales of all apples regardless of areas of origin were 20 percent, and 9 percent greater respectively, when the apple use and the general health themes were employed as compared with no promotion. Carryover influence of a given theme on sales of apples in the subsequent period was minor. In addition to the effects directly associated with the promotional themes, the sales of apples from all regions were affected by apple prices, amount of retail display area devoted to the apples, and amount of display area given to grapefruit.

Promotional expenditures of agricultural producer groups. This study was undertaken to determine the scope and types of promotional activity, including expenditures by media, of organized agricultural groups sponsored jointly or separately by producers, processors, and distributors. Approximately 1,100 agricultural commodity groups including cooperatives spent about \$67 million for promotion during a fiscal year which in most instances ended in 1958. These groups indicated they planned to budget about \$72 million for promotion in the following year. More than 50 percent of total promotional expenditures was in the form of advertising. Public relations and consumer education accounted for 23 percent, and merchandising aids 17 percent. Fruit products alone accounted for 30 percent of total promotional expenditures. Promotional programs, national in size, accounted for 48 percent of all promotional expenditures, State and local programs 36 percent, and regional programs the remaining 16 percent.

Plans: Work will continue on the development of an advertising and promotional procedures manual in 1961. A final report on the effectiveness of the promotional program for Washington State apples entitled "Relative Effectiveness of Special Promotional Programs for Apples on Sales of Apples and Selected Fruits," will be released. Additional work on advertising effectiveness will be undertaken depending upon the needs and requests of the industry. It is anticipated that resurveys will be conducted from time to time on promotional expenditures made by agricultural groups.

Publications: Promotion of Farm Products by Agricultural Groups, Frye, R. E. and Grubbs, V. D. MRR 380, January 1960.

B. Measurement and Evaluation of Market Quality

6. OBJECTIVE MEASUREMENT OF MARKET QUALITY FACTORS

MQ

Problem: New and improved methods and techniques of identifying and measuring quality factors in deciduous fruits and tree nuts are needed to provide better inspection, grading, and standardization of these commodities.

Program: A continuing program of applied and basic research conducted at Beltsville, Maryland, and involves about two professional Federal man-years annually.

Progress: Peaches. Evaluation studies on twelve breeding lines and varieties were continued with emphasis on adaptability of the fruits to baby food purees. Products from three commercial brands, representing both cling and freestone types, were used as references.

The established variety Coronado and breeding lines 3-3080 and FV 89-89 were equal to the best of the commercial brands in appearance. Breeding lines, 3-2510, 3-3169, and the established varieties Red Globe, Red Haven, Ambergem and Elberta were significantly poorer than the best commercial brands in appearance. Late harvested fruits of Selection 2422 contained so much anthocyanin in the flesh that the puree became brown after storage. In general, the flavor rating of purees from the experimental breeding lines was superior to that of the commercial brand samples, particularly over those made from clingstone varieties. Those ranking highest in flavor included selections 2422, 3-2510 and FV 89-89 and the established varieties Coronado, Fortuna, Red Haven and Red Globe.

Strawberries. Evaluation studies of the freezing quality of new breeding lines and varieties continued but at a reduced rate due to poor yield of plots. Of these, selections U. S. 2593, NC 2477, and the established varieties Earlidawn, Dixieland and Surecrop received high rankings for appearance of the frozen slices. Tennessee Shipper, U. S. 2595 and Redglow ranked fairly good to good; while U. S. 2601, 2664 and Vermilion received poor rankings for appearance.

The flavor ranking of most of the samples was relatively high. U. S. 2593, NC 2477, Earlidawn and Vermilion received high flavor scores. Selection 2664 was poorest in this regard and the samples of Dixieland did not rank as well as is usual for this variety. As has been noted in past years, not all of those varieties of good appearance rank well for flavor and vice-versa.

Objective color measurements of varieties and breeding lines which received high ratings on appearance indicated that the Rd value should be about 4.5 with a dominant wavelength approaching 600 mu to receive good rating for the color aspect of appearance. Poor varieties and breeding lines usually had higher Rd indicating lightness and dominant wavelength below 590 mu.

Red Tart Cherries. Exploratory research on color measurement by light transmittance continued during the 1960 season. Emphasis was placed on the detection of scald following internal bruising which has been shown to interfere with color measurement in previous work. The difference in optical density between measurements made at 695 and 780 μ showed good possibilities for detection of this condition. In holding tests of bruised cherries this measurement showed changes before the condition was visible externally. Transmittance curves on maturing cherries were also taken. It may be possible to detect scald following internal damage of cherries by light transmittance measurements at one set of wave lengths and to measure color of the sound cherries at another.

Apples. Studies on the use of light transmittance techniques to indicate maturity and storage condition of apples continued. Lots of fruit of two varieties, Red and Golden Delicious, of numerous harvests were separated on the basis of light transmittance measurements into three groups of relatively high, medium, and low chlorophyll content. These were stored and samples removed at two-week intervals. Light transmittance measurements, chlorophyll analyses, and pressure test readings were made on these samples to show the progress of ripening in storage. The decline in chlorophyll content and accompanying light transmittance readings was relatively rapid during the first sixty days of storage, then much more gradual during the remainder of the period of more than nine months. The three groups which were separated on the basis of their chlorophyll contents remained fairly distinct through this long storage period. A calibration curve of chlorophyll content vs. transmittance reading based on 204 readings was made for Golden Delicious.

Exploratory work on detection of water core by light transmittance equipment indicated that this defect could be detected by measurement of the optical density difference 750 - 800 μ .

Plans: Evaluation studies on varieties and breeding lines of peaches will continue at the present level. Work on strawberries will be completed after publication of the results. Plans for continued cherry work are indefinite at this time. Work on apples will be continued.

C. Product Protection during Marketing

7. POSTHARVEST PHYSIOLOGY AND STORAGE

MQ

Problem: There is a need to extend the marketing season to permit more orderly marketing of our deciduous fruits and tree nuts. Applied research on storage methods and basic research on product responses to storage are needed to better maintain quality and reduce spoilage.

Program: A continuing long-term program involving basic and applied research on the varied storage requirements of different types and varieties of fruit to learn the ideal conditions under which each should be stored is conducted at Fresno, Calif., Pomona, Calif., Wenatchee, Wash., Raleigh, N. C., and Beltsville, Md., and involves about five professional Federal man-years annually plus contract work at the Rhode Island Experiment Stations to investigate apple scald.

Progress: Controlled-Atmosphere Storage of Northwest Delicious and Golden Delicious Apples. Controlled-atmosphere (C.A.) storage was more beneficial to Delicious apples in the 1959-60 season than in any of the previous years of experimentation, but overall benefits were not outstanding. The average flesh firmness of the C.A. fruit when the rooms were opened on May 19 was 15.2 pounds and total acids averaged 0.214 percent. Corresponding figures for similar fruit from regular storage were 13.5 pounds and 0.134 percent, respectively. The C.A. fruit was consistently rated higher than the check fruit by tasters, but the margin was not great. A taste panel of 5 members rated the C.A. fruit fair with an average numerical rating of 75.3 and the check fruit fair with an average numerical rating of 72.0.

Ozone effectively reduced ethylene in the C.A. storage room atmosphere. A small commercial ozonizer, operated 2 hours per day, maintained the ethylene level at about 50 parts per million. The non-ozonized room contained approximately 700 p.p.m. of ethylene at the end of the storage season. However, at the temperatures maintained in the C.A. rooms (about 31°F.) ethylene appeared to have no effect on ripening or quality of the fruit.

Monethanolamine continued to be a good scrubbing agent for the removal of carbon dioxide from the storage atmosphere. The same solutions employed the previous year were reused this season with very little loss of absorptive capacity.

Studies of C.A. storage to date have shown no effect on shelf-life or breakdown of Delicious apples as compared with conventional storage.

Controlled-atmosphere storage of Yellow Newtown apples. A water scrubber was developed to remove excess carbon dioxide from commercial C.A. storages. The scrubber employs the venturi principle and a special diffusing head to mix larger volumes of fresh air with water in a cylindrical column. The carbon dioxide is picked up in the water that passes over a unit cooler in the storage room and is dispelled as it mixes with

the air in the scrubber. A single scrubber, when operated 12 to 16 hours per day, is capable of maintaining 6 percent carbon dioxide in a 40°F. room holding 38,000 boxes of apples. Four large C.A. storages in the Watsonville, Calif. area are using this scrubber and report savings over the use of caustic, less corrosion of equipment, and more uniform maintenance of CO₂ levels.

Controlled-atmosphere storage of strawberries. The effects of controlled atmospheres for strawberries were studied a second year. Starting with strawberries in various stages of coloration (under 25 percent through full red color) berries were stored at two temperatures in atmospheres of 0, 5, and 10 percent CO₂ in combination with 1, 3, 10, and 20 percent O₂ for two weeks. At 50°F. CO₂ retarded color development almost completely at all levels of O₂. At 32°, partially colored berries failed to develop red color in any C. A. or air treatment. Upon removal to air at 70° both the 50° and 32° stored fruit developed full-red color within 4 days.

Decay was lower in strawberries stored in C.A. than in air-stored fruit; it was lowest in chambers with only 1 percent O₂. Off flavors (fermented) were noted in 4 of the treatments stored at 50° F., check in air, and in chambers with 1 percent O₂ in combination with 0, 5, and 10 percent CO₂. With the exception of the air-stored fruit off-flavor was associated with low O₂.

Controlled-atmosphere storage and film liners for cranberries. The feasibility of using polyethylene liners or controlled atmosphere to extend the storage life of cranberries was examined at the request of the cranberry industry. Cranberries were stored at 32° and 38°F. in atmospheres of 0, 5, and 10 percent CO₂ in combination with 3, 10, and 21 percent O₂. Other lots were stored in air and in 1.5-mil polyethylene crate liners. After 2 month's storage, there was little difference in quality of the fruit in the various treatments; all were essentially as good as when placed in storage. After 4 month's storage, fruit in the controlled-atmosphere chambers and in film liners was in worse condition than check samples stored in air. The percentages of salable cranberries at this time were: check in air 52 percent, C.A. treatments 6 to 44 percent, and film liners 1 to 3 percent. These very poor results with the experimental treatments may have been due to higher humidity which favored decay in the chambers and liners.

Modified-atmosphere storage and ripening of plums. Preliminary storage and ripening experiments with the relatively new Nubiana plum variety indicated that these plums may be still immature when fully colored. Fully-colored plums picked July 30 did not ripen to good dessert quality, when ripened immediately after harvest, or after 6 weeks' storage at 32°F.

Modified atmospheres in sealed polyethylene liners did not appreciably retard ripening of Eldorado plums during transit to the New York market. The ineffectiveness of the modified atmospheres may be attributed to the short time in transit.

Control of scald on Eastern-grown apples. Scald was severe during the 1959-60 season. Conventional mineral-oil wraps often gave little or no control. Three chemicals, diphenylamine (DPA), Santoquin, and dimethyl-diphenyl-urea (DDU) were evaluated. The best control of scald was obtained with DPA used as a post-harvest dip at 2000 p.p.m. Chemical injury from the DPA was very slight on Delicious, Stayman, Rome, York, and Grimes Golden but severe on Golden Delicious apples. Wraps containing 1.5 mg of DPA and mineral oil were better than standard oiled wraps, but not as effective as a DPA dip, DDU, which has shown promise on some European varieties, was ineffective at 3000 p.p.m. on Rome and Stayman varieties.

Santoquin, which has now been approved by F.D.A., was considerably less effective than DPA when used as a dip but was somewhat better than oiled wraps in most tests.

Sprays applied 1 day before harvest using 2000 DPA or 2811 p.p.m. Santoquin gave little or no scald control.

Control of scald on Western-grown apples and pears. DPA in a wettable powder formulation was tested as a preharvest spray and postharvest dip for the second year. A wettable powder containing DPA and captan, and an emulsifiable formulation containing Santoquin were tested for the first time in preharvest and post-harvest applications on Delicious and Winesap apples and in a post-harvest application on Anjou pears. Preharvest applications failed to control scald on apples. DPA and DPA plus captan used in postharvest dips markedly reduced scald in apples. Santoquin was less effective than DPA on apples, but more effective on pears.

Toxicity of diphenylamine. Feeding tests being conducted at the Western Utilization Laboratory indicate that a dietary level of 1.0 percent DPA inhibits growth in both dogs and rats. Some inhibition of growth was also obtained at the 0.5 percent levels in rats and 0.1 percent levels in dogs. The data obtained to date would not preclude the use of DPA on apples but a full evaluation can not be made until all tests are completed.

Structure and character of apple skin as related to apple scald. The thickness of the cuticle of 4 varieties of apples was found to vary as much as 60 percent between varieties during this 3-year study. No definite relationship between scald susceptibility and thickness of cuticle could be found for McIntosh, Cortland, Yellow Delicious and Grimes Golden varieties. Year to year values for cuticle thickness within a variety were found to differ as much as 40 percent. More severe scald occurred in the years when the cuticle was somewhat thicker.

Although the green side of a red apple is usually the first portion of the apple to show scald, no appreciable difference in thickness of the cuticle was found on the two sides of 3 varieties of apples. Weight of cuticle per unit area of apple increased during storage but thickness decreased slightly. Neither measurement showed any relationship to the development of scald.

Apples rubbed with pumice powder at harvest time did not develop scald in storage. Microscopic examination of the cuticle of treated apples revealed deep furrows which would tend to reduce the effective thickness of the cuticle. There is some indication that factors either natural or artificial that tend to produce a thinner cuticle within a given variety will also tend to reduce storage scald. This relationship does not hold between varieties and does not explain many other variations in scald development.

Soft scald of Northwestern apples. Rapid cooling near freezing temperatures has been shown to increase soft scald of apples, especially when the apples are warm and have a high rate of respiration. At present in the Northwest, there is much interest in hydrocooling as a possible means of extending storage life of apples, but its effect on the development of soft scald is not known. Tests run this year in which mature Delicious apples were hydrocooled to a core temperature of 36°F. and then placed at 30° failed to produce soft scald. Likewise, none of the disorder occurred in the check fruit placed in 30° storage without hydrocooling. There was slightly more storage scald in the hydrocooled apples than in the check fruit (non-hydrocooled).

Aging of plant tissues as related to polyphenol substances. Apples were sampled weekly during growth in July, August, and September and after harvest and storage in October through January to determine the types and quantities of polyphenol substances present. These substances prepared in water and ethanol extracts of the apple tissue were detected by ultra-violet absorption spectra and separated into a number of components by paper chromatography. Attempts are being made to associate the occurrence of some of these compounds with the aging process in apples.

Quality changes in McIntosh apples during marketing. Samples were obtained from 3 lots of eastern-grown McIntosh apples before and after packing into 3 - or 4-lb. polyethylene bags in the Hudson Valley region, on arrival at retail stores in New York City, while on store shelves, and after holding up to 6 days at 70°F. in the laboratory. Stem punctures and bruising were the most serious defects found in all the samples. Punctures and bruises increased during grading and packaging, in transit to retail stores, and while on the store shelves. Retail store samples obtained from the first day and second day displays were very badly damaged by punctures and bruises. When held 5 to 6 days at 70°F. samples obtained from retail displays developed 20 to 50 percent decay. About 95 percent of the decay occurred in punctured or bruised tissue.

New procedures for fumigation of grapes. Research to improve the fumigation of table grapes with sulfur dioxide has been directed toward 1) improved distribution of the gas in refrigerator cars, 2) improved gas distribution in cold storage rooms, and 3) greater kill of the causal organism by carefully controlling concentration, exposure time, humidity, and temperature during fumigation.

Emperor grapes packed in consumer packages and loaded in standard ice-bunker refrigerator cars could not be fumigated properly even when

a supplemental fan was placed in the brace of the car to help disperse the gas. Effective amounts of gas did not reach fruit in the over-wrapped consumer packages within the load, but excess amounts (over 1.2 percent) persisted at the periphery of the load.

Fumigation of a mechanically refrigerated rail car through a gas tube inserted in one of the floor drains produced harmful concentrations (over 1.25 percent) of gas near the point of release. Distribution was greatly improved by passing the tube through the drain to a point above the load and releasing the gas in the airstream. A maximum concentration of 0.55 percent sulfur dioxide was reached under these conditions. Similar results were obtained by releasing the gas in front of the circulating fans in the ceiling plenum chamber. The doors of mechanical cars had to be opened at the end of fumigation to rapidly disperse the gas from the car.

Maximum gas concentrations in a cold storage room one-quarter full of Emperor grapes that was fumigated with a calculated 0.25 percent sulfur dioxide were as follows: 0.20 percent in the channels between pallets, 0.12 to 0.17 percent in the space between boxes at the center of a pallet, and 0.10 percent or less in the center of a lug box.

Improved fumigation techniques developed under this project are being applied by several large grape shippers. These techniques have improved the quality of table grapes by reducing sulfur dioxide injury and improving decay control.

Varying apple storage temperatures in marketing channels. Jonathan, Delicious, and Winesap apples were subjected to alternating temperatures of 32° and 50° F. at weekly intervals. Comparable fruit were held at a constant effective temperature of 43.5° F. based on a Q₁₀ value of 3. Only a minor differences in respiration rates, acetaldehyde contents, pressure tests, or decay were indicated in these tests when the fruit was alternated between 32° and 50° at weekly intervals, and that held at a constant effective temperature of 43.5° F. In these tests Delicious Apples accumulated much more acetaldehyde during the storage period than did the Jonathan and Winesap varieties.

Condition of dried fruit in retail stores. Research was initiated (1) to compare the quality of dried fruit in retail stores with the initial quality of dried fruit after packing, (2) to determine temperature and relative humidity in retail stores and the length of time dried fruits remain in marketing channels, and (3) to determine the effect of retail environments and marketing time on dried fruit quality. The criteria of quality adopted for this purpose were: a subjective evaluation of flavor, texture, and appearance; and objective measurements of color (optical density of a 50% ethanol extract), moisture content, and sulfur dioxide content (for cut fruits only).

The retail sampling is about half completed, but it is already clear that 5 to 10 percent of the apricot and prune samples, 10 to 15 percent of the raisin samples, and 20-25 percent of the fig samples have deteriorated and are of poor quality. Most of the low-quality

fruit had been in marketing channels for more than 20 weeks. It appeared that most of the deterioration was due to the long period that the dried fruit was held at relatively high temperature in retail stores.

Storage and packaging of strawberry plants. The recently developed method of packaging and storing strawberry plants in polyethylene-lined crates has improved quality of commercial stock and created a demand for stored plants. Studies on storability as related to plant maturity and storage temperature have been conducted on several varieties. Climatic conditions prior to digging plants for storage had a pronounced effect on condition of plants and their keepability. Varieties differed considerably in storage behavior; the Albritton variety was particularly difficult to store.

Plants dug after December 6 in Maryland and stored at 30° F. were in excellent condition on removal from storage in April. Storage of strawberry plants at 24° killed early dug plants and was no better than 30° for storing later-dug plants. Plants stored for more than two months at 32° or 36° developed new root and top growth, which is undesirable. Also, decay of early-dug plants stored for more than two months at 36° was excessive. No decay developed in plants stored at 30°.

Freezing points of grapes. Freezing points of grapes and grape stems for three important commercial varieties were determined as follows: Thompson Seedless - freezing point of fruit 24.7 to 26.5° F., averaging 25.5°; freezing point of stems 26.3°. Tokay - freezing point of fruit 24.3 to 25.2° F., averaging 24.6°; freezing point of stems 25.5°. Ribier-freezing point of fruit 24.0 to 25.9° F., averaging 25.1°; freezing point of stems 25.0°.

Storage and quality maintenance of blueberries. Ten commercial lots of fresh blueberries (5 varieties) were examined before and after being held at 32°, 40°, and 50° F. for 1, 2, 3, and 4 weeks. A subsequent examination was made after 2 days at 70° following storage. Initial spoilage of commercial significance averaged about 6 percent and gradually increased during 4-weeks storage to about 18 percent in 32° F., 30 percent in 40°, and 70 percent in 50°. After 2 days at 70° following storage for 4 weeks, spoilage increased to 36, 55, and 82 percent for blueberries stored at 32°, 40°, and 50° respectively. Two days at 70° alone increased spoilage from an initial 6 percent to 11 percent.

Weight loss averaged about 1 percent per week at 32° F., slightly over 1 percent per week at 40°, and 2 percent per week at 50°.

Short intervals between picking produced more acid fruit with better keeping qualities than long intervals confirming results previously obtained.

A device for testing forced air cooling of single packed crates was constructed and tested. Rate of cooling was increased from about 3 degrees F. per hour (in commercial stacks) to about 20 degrees in the first hour with an initial temperature differential of 35 degrees. This rate was increased to a 20 degree reduction within 3/4 hour by modifying the crate ventilation. Rate of cooling was increased further by using mesh-plastic cups instead of the standard veneer cup.

Plans: C.A. storage studies with apples will be continued, particularly the influence of maturity at harvest on the storage life and quality of C.A. fruit and the tolerance of Delicious and Golden Delicious apples for various percentages of CO₂. Work on controlled-atmosphere storage of cranberries and strawberries will be continued with particular emphasis on attempts to reduce the relative humidity in the C.A. chambers. The effectiveness of several fungicides for reducing postharvest spoilage of berries also will be investigated. Santoquin and DPA for scald control will be tested further with emphasis on formulations to improve effectiveness and prevent injury. The compatibility of DPA and Santoquin with fungicides will be determined. The feeding of rats in the DPA toxicity study is completed. The dog feeding tests will be completed early in 1961 and a final report should be available by mid year. Studies on the relation of skin structure to apple scald and studies on the freezing point of grapes are completed.

Further hydrocooling tests are planned with Jonathan or Grimes Golden apples to determine the effect on soft scald development.

The work on storage and ripening of plums, retail sampling of dried fruit, quality changes of McIntosh and Delicious apples during marketing and storage of strawberry plants will be continued. Work on distribution of sulfur dioxide in grape loads and in storage will be continued. Manuscripts detailing the effects of polyphenols on oxidative phosphorylation of apple mitochondria and on packaging and storing blueberries will be completed. Further work on forced air cooling of blueberries will be conducted.

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C. Product Protection During Marketing

8. POST HARVEST DISEASES

MQ

Problem: Effective fungicides and other measures are needed for better control of decay of deciduous fruits as they move from the growers through various marketing channels to the ultimate consumer.

Program: A continuous long-term study of decay pathogens at market laboratories in New York City and Chicago and applied research at Fresno, California, Wenatchee, Washington and Beltsville, Maryland, on materials and methods for reducing decay during storage, transit, and marketing and for forecasting storage decay, involving approximately four professional Federal man-years annually.

Progress: Decay control with sweet cherries. Captan and the sodium salt of dehydroacetic acid (DHA-S) were compared as dips for Bing cherries. Captan (80% wettable) was used at the rate of 1/2 lb. active ingredient per 100 gallons of water. DHA-S was used at the rate of 4 lbs. per 100 gallons of water. The fruit was held for 5 days at 36° F. and 5 days at 70°. There was no decay in any of the fruit after 5 days at 36°. Decay in inoculated fruit after 5 days at 70° was reduced about 50 percent by the captan dips. The DHA-S dip was not consistently better than the control. Captan is now being used commercially as a fruit wash to prevent decay of sweet cherries.

Forecasting the development of the bull's-eye rot in apples. In a study of the enzymes of the blue-mold organism (Penicillium expansum) and the bull's-eye rot organism (Neofabraea perennans), it was found that the culture filtrate from Penicillium expansum produced an 80 percent reduction in the viscosity of a pectin solution in 10 minutes and a 96 percent reduction in 80 minutes. The percentages reduction for Neofabraea for the same periods were 17 and 55 percent, respectively. This confirms information obtained last season on the greater ability of Penicillium than Neofabraea to break down pectins and may explain the faster invasion of tissues by blue mold than by bull's-eye rot.

One fruit organization with 9 packing houses reported that the early marketing of certain lots of fruit which the forecast technique (developed under this project) indicated would develop disorders, resulted in savings of approximately one-half million dollars in a single season.

Decay control in Northwestern apples. Chemical injury, which looked like storage scald, developed on commercially packed Wine-saps that were treated with captan. The injury was reproduced experimentally by treating Winesaps with captan and was shown to be associated with the wax which developed on the fruit in storage.

Winesap apples, inoculated through puncture wounds and dipped in fungicides were held for 7 days at 65° F. Of five materials used at several concentrations substantial decay reduction was obtained only with captan and phaltan at 1200 p.p.m. and dehydroacetic acid at 4800 p.p.m.

Delicious apples which had been cleaned and polished with Saran brushes developed about twice as much decay as unbrushed fruit from the same lot. There is evidence to indicate that invisible injuries produced in brushing may be responsible for the increased decay.

Decay control in Northwestern peaches for processing. In this study 40 field boxes of peaches from each of 8 orchards were collected and the fruit from each orchard was divided into 4 lots of 10 boxes each. One lot of fruit from each orchard was ripened immediately in a commercial ripening room at 75° F., while one lot each was stored at 31° F. for 7, 10, and 14 days, respectively, before ripening. Decay after ripening 4 days at 75° F. was 23.8 percent in fruit that had not been refrigerated and 22, 19, and 10.1 percent, respectively, on fruit that had been refrigerated 7, 10, and 14 days.

Aerial mycelium developed abundantly on the fruit that had not been refrigerated. There was less mycelium on the fruit that had been in storage for 7 days, still less on the 10-day fruit, and virtually none on the fruit which had been stored for 14 days.

As a result of this research three major peach canneries in the Yakima area are using cold storage prior to ripening.

Peaches inoculated through wounds were incubated at 65° F. for 24 hours and then stored at 31° F. for 7, 10, and 14 days, respectively, before ripening. Decay was discernible at the margins of the wounds within 48 hours after inoculation in fruit that was ripened without refrigeration. In fruit ripened after 7 and 10 days cold storage, decay at the margins of the wounds was discernible after 72 hours ripening and in fruit ripened after 14 days in cold storage, 96 hours were required for decay to start.

Factors affecting decay in Eastern peaches. Germination of dormant *Rhizopus* spores held 10 days on agar at temperatures ranging from 30° to 40° F. and then transferred to 75° for 1 day was 50 to 80 percent less than that of spores not exposed to the low temperatures. Spores held 7 days at low temperatures had approximately 25 percent reduction in germination. Germination of those held 2½ days at low temperatures was approximately the same as the controls.

Germination or growth from dormant or germinated spores of the brown rot organism (*Monilinia fructicola*) was not affected by exposure to temperatures as low as 24° F. for 10 days before placing them at 70°.

Germination and growth from dormant Rhizopus spores were more adversely affected by exposures from 95° to 110° F. than that of Monilinia spores. Germination and growth from spores of both organisms at 75° were prevented by previous exposure to 110° for two hours.

A model hydrocooler with a capacity up to four bushels was constructed and is currently being used in tests to determine the practicability of using appropriate fungicides in the hydrocooling water to reduce brown rot and rhizopus rot of peaches. Factors being studied are the maintenance of the desired concentration and pH of chemicals in the hydrocooling water, practical analytical procedures for determining concentration of the chemicals, and the effectiveness of the fungicides for controlling decay during simulated transit and marketing periods.

Decay control in California strawberries. Post-harvest decay of California strawberries is caused primarily by gray mold (Botrytis sp.) at low temperature and by Rhizopus sp. at high temperature. Refrigeration near 32° F. controls Rhizopus, but not gray mold rot. To reduce the latter, berries were fumigated with sulfur dioxide (SO₂). Related studies have shown that very low concentrations of this fumigant killed spores of Botrytis cinerea when the relative humidity was high. Concentrations from 100 to 500 p.p.m. for various exposure times were tested to determine the doses that reduced decay and that could be tolerated by the berries.

Five-hundred p.p.m. SO₂ for 15 minutes injured berries at bruised areas, but 300 p.p.m. for 30 minutes did not. Either treatment reduced the number of decayed berries to about one-half that in untreated lots.

Gamma irradiation of grapes in commercial lugs. Emperor grapes which had been in commercial storage for 7 months were irradiated in commercial LA lugs. Duplicate 56 lb. lugs of fruit were irradiated simultaneously with doses of 200,000, 300,000, 400,000, and 500,000 rads at a rate of 37000 rads/min. After irradiation half of the lugs of fruit were held for 8 days at room temperature and the remainder for 21 days at 35° F. Decay did not develop in the treated grapes at any dose level or in untreated grapes. After 8 days at room temperature no skin color changes were noted at any of the doses. Flavor of the grapes treated at 500,000 rads was unpleasant. At the lower doses flavor scores were equally divided between pleasant and unpleasant, while the untreated grapes were scored pleasant in most cases. Texture of the flesh was soft following 500,000 and 300,000 rads but firmer at 400,000 and 200,000 rads and in the controls.

After 21 days at 35° F., skin browning was evident at the 500,000 rad level but not at the other doses. Flavor was unpleasant at 500,000, 400,000, and 300,000 rads, but not at 200,000 rads nor

in the untreated grapes. Texture was soft at 500,000 and 300,000 rads, questionable at 400,000 and 200,000 rads. It was satisfactory in the untreated grapes.

Storage diseases of chestnuts. Over 75 percent of the kernel decays were caused by fungi identified as Phoma castanea, Dothiorella sp., Cytodiplospora castanae and Pestalotia sp. These fungi apparently invade the kernel from the succulent burr tissue at or shortly after harvest. Shelling and removal of the kernel integument at the time of harvest would permit the careful, early grading necessary to prevent inspection. Shelled kernels might be stored at 32° F. and marketed in consumer bags.

Identification of market diseases of peaches. Pustular spot on peaches caused by Clasterosporium carpophilum was found to advance most rapidly at 70° F. Infections on fruits are controlled at 40° and delayed at 80°. Fruit infection becomes visible 3 to 4 days after inoculation at temperatures of 70 to 75° and within 5 to 6 days at 80° and 54°, respectively. Spore germination tests showed that some spores can germinate at 40°. Inoculated peaches held at 40° did not show signs of the disease but developed visible infections upon removal to higher temperatures. Results indicate that incipient infections are established at 40°. They confirm earlier observations that visible symptoms of this disease may develop during transit.

Studies on the physiology, morphology, and taxonomy of the yeast causing a softening and sour pit of canning peaches have been completed. The causal organism has been determined to be similar if not identical to Torulopsis inconspicua.

Identification of market diseases of strawberries. The occurrence of Gloeosporium rot of strawberry was noted on fruit from Louisiana. Detailed studies were made of mycelium, fruiting bodies and spores of the fungus. Neither setae nor a perfect stage of the fungus were observed on any media or hosts. Inoculations with spore suspensions were positive on ripe, wounded, or sound fruit. Studies with Gloeosporium on agar indicate that the minimum temperature for growth was 45° F., the optimum 80°, and the maximum temperature at which growth will occur about 97°. This is believed to be first such record of Gloeosporium on strawberry fruit in the United States.

Plans: Studies on Pustular Spot of peaches, Gloeosporium rot of strawberries, and storage diseases of chestnuts are completed. Tests on decay control of Northwestern apples will be continued with emphasis on determining compatibility of captan, Stop-Mold, and DHA-S with scald inhibiting chemicals. The histological and biochemical studies of bull's-eye rot on apples will be continued. Decay-control studies with peaches will be continued. Further work with sulfur dioxide and for decay control of strawberries are planned. Irradiation studies will consist largely of testing the effects of dose

rates. In studies on control of post-harvest diseases emphasis will be placed on effects of handling, temperatures, host-parasite relationships and other factors that involve control of these diseases with a minimum use of chemicals.

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9. MAINTAINING QUALITY DURING TRANSIT

MQ

Problem: There is a need for reliable information on methods of loading and transit protective services for fruit as a result of adoption of new containers, new types of rail and truck equipment, faster rail schedules, and heavier loads to take advantage of incentive rates.

Program: A continuous program of precooling and shipping tests conducted in cooperation with growers, shippers, carriers, and receivers by personnel at Wenatchee, Washington, Fresno, California, Beltsville, Maryland, Chicago, Illinois, and New York, N. Y., and involving this past year about one professional Federal man-year. The work with California pears is conducted in cooperation with the California Tree Fruit Agreement.

Progress: Protective Services for California Bartlett Pears. The results of the 1959 tests on modified protective services for rail shipments of California Bartlett pears that permit initiation of ripening in transit were made available to shippers through two publications and three oral presentations. As a consequence, modified icing has been used more extensively than ever before and market gluts of early unripe fruit have been largely avoided in the current season. The quality of the fruit and the market returns have been better than average due, in part, to the application of these research findings.

This season tests were made to determine transit temperatures and subsequent ripening in Bartlett pears shipped to New York in cars pre-iced to half-stage capacity, replenished at Roseville, California, and re-iced only once in transit. Council Bluffs (Iowa), Chicago (Illinois), and Marion (Ohio) have been compared as single re-icing stations. Comparisons were also made of fruit shipped in mechanically refrigerated cars in the Cargotemp car, and in a conventional car. Thermostats in the mechanical and Cargotemp car were set at 55° F.

Plans: Further shipping tests are planned with California pears having high initial temperatures and firmness somewhat below 20 pounds. Modified services for pears shipped to the Chicago market will also be studied. Pear shippers in the Wenatchee area have indicated a desire to participate in future tests.

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10. PROTECTION OF DRIED FRUIT AND NUTS AGAINST INSECT ATTACK

MQ

Problem: Because of serious damage from insect infestations in dried fruits and nuts, there is a need to develop new and improved methods of preventing and controlling such infestations from time of harvest until they are consumed.

Program: A continuing long-term program involving applied laboratory and field studies on the development of new and improved methods of preventing and controlling insects attacking or affecting dried fruits and nuts carried on at Fresno, California, and basic research on the development of insect-resistant packages and the chemical residue studies at Savannah, Georgia, involving 3 professional Federal man-years annually.

Progress: Protection of Packaged Fruit and Nuts. In the evaluation of the insect resistance of various types of packages used for dried

fruits and nuts, bags made out of Mylar were more insect-proof than those made of cellophane or pliofilm, and foil overwraps were more effective than paper overwraps for excluding insects from shell cartons. Polyvinylidene chloride film (Saran) was very effective in protecting nut meats from insect infestation if the bags made of this material had perfect end closures.

Laboratory tests showed that pyrethrum dust sprinkled over the tops of shell cartons packed in shipping cases was not effective in preventing insect infestation of the raisins contained in the packages.

Drosophila Control Studies. Using adults tagged with radioactive phosphorus, it was determined that drosophila can fly a distance of 4.4 miles in 48 hours. July 1959 weather was too hot to favor fly development but cooler weather in August stepped up breeding rapidly. Field tests with 3 types of yeasts as attractants showed champagne yeast to be superior to baker's or wild (S-134) yeasts.

Excellent control of drosophila at a peach dump was obtained by spraying with dicapthon. In vineyard plots, bunch infestation was reduced by using malathion, dimethoate, O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate (Diazinon) and 1,2-dibromo-2, 2-dichloroethyl dimethyl phosphate (Dibrom).

Preliminary tests showed that Argon light is not very promising for attracting drosophila.

Plans: Studies on the development of insect resistant packages for dried fruit and nuts will be continued with emphasis on determining the most resistant packaging materials and designs now available. Limited research will be initiated on the development of fumigation methods and dosages for nuts which will be effective without leaving objectionable residues. Field studies on drosophila will be concluded and research will be expanded accordingly on the development of methods for controlling and preventing drosophila infestations in wineries and raisin dehydrators.

Publications: Experiments in Chemical Control of Drosophila in Fig Orchards and Vineyards. A. P. Yerington, E. M. Stafford, and H. Kido. Proceedings Fourteenth Annual Research Conference of the California Fig Institute, pp. 33-35. February 16, 1960.

11. IMPROVED CONSUMER PACKAGES AND SHIPPING CONTAINERS

TF

Problem: To develop and evaluate new and improved consumer packages and shipping containers, including inferior packaging materials which: (1) Are cheaper and more efficient to pack and handle; (2) enable lower transportation costs; (3) protect the product from damage; (4) reduce waste and spoilage losses; (5) command favorable trade and consumer acceptance; and (6) permit increased

package and container standardization.

Program: A continuing and varied research program in cooperation with State agricultural experiment stations, fruit growers, shippers, and distributors throughout the country, and involving approximately three Federal professional man-years.

Apples. Almost 25,000 boxes of Washington State apples in experimental consumer packages were successfully shipped by rail to eastern markets during the 1959-60 season. These new packages appear very promising. They protected the apples from bruising, improved their appearance and salability, met with favorable trade and consumer acceptance, and offer possibilities for increasing returns to apple growers. The packages were two types of molded pulpboard trays -- each in two sizes, one for six apples and one for eight. One tray, used on a limited scale the previous year, was high-sided and the second tray, developed during the shipping season, was low-sided. Apples packed in both trays in both sizes were loosely sleeve-wrapped in a new biaxially oriented polyethylene film. The wrapped trays were moved through a heat tunnel. The film shrank tightly around tray and apples, completely immobilizing the apples. For materials and labor, it cost about 2.7 cents a pound to pack the apples in the high-sided tray package and 2.3 cents a pound in the low-sided consumer tray. This contrasted with a cost of 1.5 cents a pound for apples of comparable size in the conventional bulk tray pack. However, apples in the consumer packages brought higher prices, 60 to 75 cents per box.

In 10 cross country rail shipments, very slight and slight bruising of Winesap apples in the shrink film packs averaged but 3.6 percent. There was no damage by bruising and no serious bruising. Most of the consumer packages were shipped in full carloads; therefore, exact comparisons with apples in the conventional pack were not possible. However, transit simulation tests in the laboratory indicated that apples in the consumer packages sustained less than one-fourth as much bruising as apples in the conventional bulk tray pack. The incidence of bruising in the low-sided trays was less than in the high-sided trays possibly because the Winesaps being packed seem to fit better in the former.

Most packages arrived in the markets with a tight, clear wrap. On a few packages, more often the ones with high sides, the film was loosened because the trays absorbed moisture and became limp. Occasionally after some time on display without adequate refrigeration, the film tended to cloud. This discoloration was believed to result from a reaction between the polyethylene film and the esters given off by the apples. Retailers liked both trays but were more inclined to favor the low sides because they permitted greater visibility.

Late in the season, preliminary studies also were made to evaluate

the packaging of soft flesh McIntosh apples. The apples were placed in trays and immobilized by wraps of shrink film. Some slight bruising occurred in test shipments. Some of the unit packages were placed on ends and some on sides in the master container for comparison with the conventional pack of traps placed on bottoms. When trays were on ends the cheeks of the apples did not sustain as much bruising because the vertical weight was carried by the tops and bottoms of the apples. When trays were placed on sides the vertical weight was still on the cheeks and bruising was not reduced. Modifications of the shallow trays were recommended to increase the height of the ends to increase protection and to eliminate sharp edges believed responsible for some of the bruising observed.

Pears. Work completed in 1958-59 indicated that it was feasible to prepackage D'Anjou pears at harvest time and market them over a 5- to 6-month period. The pear packages were not overwrapped at shipping point but were placed in a consumer tray so that the retailer simply removed the package from the box and overwrapped it with film. Prepackaging in this manner reduced the amount of discoloration and bruising and enabled the retailer to receive a superior product which required about 60 percent less labor for prepackaging pears in the stores.

In 1959-60 the research was expanded in an effort to develop and improve the techniques of prepackaging and to test the feasibility of overwrapping the trays with film at shipping point. A new type of molded pulp-board tray was developed. This tray had a longitudinal center divider rather than individual pockets. This feature allowed a wide range of sizes to be packed in the tray. By using this design the packers were able to pack 80 to 165 size pears in the same size tray. For example, four 80's, five 90's, six 100's, 125's, 135's, or 150's, and seven 165 size pears were packed in the same tray. This eliminated the necessity of maintaining an inventory of 5 or 6 different size trays. By judicious use of two thicknesses of excelsior pads and by varying the number of pads used in the master container, it was possible to pack the range of 80 to 165 size pears in two master containers. which were identical except that they differed by one inch in depth.

The average cost of packing materials, including polyethylene box liner for one box of 15 packages, when each pear was tissue paper wrapped, was 84 cents and when the packages were overwrapped with cellophane film the cost was \$1.00.

In another experiment in which a slightly more expensive tray was used, the materials cost of a fiberboard master container with 16 trays with 8 tissue-wrapper pears in each was 78 cents. The cost of packing materials for the standard wood box averages about 67 cents

in the Northwest. The direct packing labor costs were 16 cents per box of tissue-wrapped pears in consumer size trays and 21 cents for pears in consumer size trays overwrapped with cellophane film as compared to 11 cents for a conventional box of pears. The additional cost of materials and direct packing labor amounted to 43 cents per box when the packages were cellophane overwrapped and 22 cents per box when the packages were not overwrapped.

Eight controlled rail test shipments (4 Bartletts and 4 Anjous) from the West Coast to East Coast markets were conducted. The prepackaged Bartlett pears showed 0.0 bruising, 7.3 percent very slight discoloration, and 0.2 percent slight discoloration, as compared to 3.3 percent bruising, 18.2 percent very slight discoloration, and 3.9 percent slight discoloration for those packed in standard wood boxes. The prepackaged D'Anjou pears showed 0.0 bruising, 1.5 percent very slight discoloration, and 0.1 percent slight discoloration as compared to 3.1 percent bruising, 3.1 percent very slight discoloration, and 0.0 percent slight discoloration for those packed in standard wood boxes.

Storage tests conducted by the cooperating grower-packer indicated that prepackaged Bartlett pears packed September 3 were in at least as good condition as comparable pears packed in standard wood boxes when they were examined after 11 weeks of storage. Similar storage examinations of Anjou pears both prepackaged and in standard wood boxes indicated that there was little difference after 13 weeks of storage but an examination after 17 weeks of storage showed that the Anjous in the conventional packs were slightly harder, and showed no scald, whereas the prepackaged pears developed a small amount of scald after being held 10 days at room temperature.

Trade reaction to these prepackaged pears was extremely favorable. The receivers were particularly impressed with the almost perfect arrival condition of the pears. They thought the packages were attractive and would do much to increase pear sales in the retail stores. Since these receivers normally prepackaged their pears before selling them they were familiar with the extra costs involved and were willing to pay a premium to cover the extra costs of prepackaging.

As a result of the research work done at shipping point in 1959-60, there will be a sizable reduction in the costs of prepackaging pears in the future. These reductions will be effected by the following: Lower per unit master container costs; a newly designed, less costly pulpboard tray; less costly films that shrink tightly around the pears and which will also reduce cushioning requirements; and semi-automatic wrapping procedures and improved packing methods.

These new packages and methods of prepackaging pears at point of production, indicate strong probabilities of delivering pears to consumers

in much better condition and at less overall cost. This should lead to improved consumer demand for pears and increase returns to pear growers.

Other Fruits. A publication covering several years research on prepackaging grapes was published in June 1960. No additional research was undertaken during the 1960 grape season. Seven different consumer packages have been packed and shipped under commercial conditions since 1956. By 1960, the grape industry was using only two -- a stapled bottom window carton and a plastic tray overwrapped with a sheet of polyethylene with many diagonal slits. These two packages were found to be most promising although neither is completely satisfactory.

Most earlier work on peach packages has been done in the Southeastern States experimenting with cell type cartons. A report was issued on this work in 1959 and in 1960 three new consumer packages were tried out on a limited scale: (1) A shallow molded pulpboard tray holding eight small peaches overwrapped with shrink film; (2) a 6-unit plastic cell tray which was left unwrapped; and (3) a 2-quart molded pulpboard tray holding about 4 pounds of peaches.

Preliminary test shipments were made with prunes prepackaged in 2-pound polyethylene bags and in 3-pound mesh bags made from polyethylene netting. The receivers reported a preference for the polyethylene bag. No cost data were obtained because of the limited production.

Packaging Studies at Central Point. The feasibility of prepackaging selected fresh fruits was explored, and new packages and packaging techniques utilizing new shrinkable films were developed at the central point level during 1959-60. Apples and pears were packaged in a paperboard tray overwrapped with the shrinkable film.

In cooperation with two eastern terminal market prepackagers, researchers helped set up pilot production lines. The pears and apples were received in conventional bulk containers. They were unpacked, unwrapped, regraded, and packed six to a paperboard tray. The trays were wrapped in the new irradiated biaxially oriented polyethylene film and moved through a heat tunnel. Eight wrapped trays were packed in a single layer in a strongly reinforced but uncovered fiberboard flat. Total packaging material and labor costs were 5.7 cents per package. Preliminary tests were also made to evaluate the use of biaxially oriented polystyrene and polyvinyl chloride films.

A 1959 report detailing terminal marketing prepackaging practices was extremely well received by produce packagers and distributors and manufacturers of packaging materials and equipment. One manufacturer wrote that the report had saved his firm \$250,000.

Shipping Containers: Peaches. Evaluation of new and improved shipping containers for peaches continued in 1960 as researchers sought a way to deliver this highly perishable fruit to market with less bruising. The 3/4-bushel basket with bulge cover was used as a control. The other containers were a 3/4-bushel basket with flat cover, a 3/4-bushel full telescope wax-impregnated moisture-resistant fiberboard box, a 1-1/9 bushel wirebound crate, a wooden box with two layers of peaches in cell-type plastic trays, and a fiberboard box with two layers of peaches in the same plastic trays. With a few exceptions, all the containers were loaded together in the same truck for shipment from South Carolina to northern markets. There were 10 such test shipments. Inspections at terminal markets indicated that the percent of bruising (total of slight, damage, and serious bruising) in the various containers was as follows: 3/4-bushel basket--bulge cover, 15.7; 3/4-bushel basket--flat cover, 11.9; 3/4-bushel fiberboard box, 7.1; 1-1/9-bushel wire-bound crate, 8.8; tray pack--wood box, 3.8; and tray pack--fiberboard box, 2.3.

Cherries. As previously reported, the new 20-pound loose pack of cherries costs about $3\frac{1}{2}$ cents a pound less than the conventional double row faced pack. If all northwestern cherries were shipped in this pack, annual savings of \$200,000 would be possible on a marketing volume of about 6 million pounds.

However, shippers moved with caution in shifting to the less expensive pack because the row face commanded a premium price that was larger than the saving. Originally this premium stemmed from the belief of auction buyers that cherries in the row face boxes were bigger and better than equivalent sizes and grades in the loose pack. Improved acceptance of the loose pack is resulting from more careful grading and more accurate sizing of loose cherries following adoption of the Federal Marketing Agreement.

The premium paid for the row face, as measured by the season average auction price for Bing cherries, declined 3.7 cents a pound between 1958 and 1959. During the first four weeks of the 1960 season the premium on the New York auction for Bing cherries in the row face was 6.12 cents a pound, as compared with 7.95 cents in the equivalent weeks of 1959. Cherries marketed in the 20-pound loose pack on the New York auction increased from 13.4 percent of the total 4-week volume in the two packs in 1959 to 19.4 percent in 1960. It is anticipated that growers will ship proportionately greater amounts of cherries in the loose pack in future years. This should reduce their marketing costs and increase their net returns if the demand for cherries remain substantially the same.

Apples and Pears. Molded pulpboard shipping trays in fiberboard boxes are now commonly used for apples and the pear industry is interested in experimenting with them as a bulk container that will improve

the arrival condition of Bartlett and Anjou pears. Two rail test shipments comparing the tray packs with conventional wood box pack were made from California and Washington. One test shipment included tight filled vibrated jumble pack pears. In these shipments, the tray pack best protected the pears from damage. The cost of the tray pack, including 5 pulpboard trays, 2 shredded newsprint pads, tissue paper wraps and polyethylene box liner was 72 cents in comparison with 68 cents for the conventional wood box. The cost of direct packing labor (based on \$1.50 per hour) for the tray pack averages 12 cents for all sizes as compared to 9 cents for the conventional wrap wood box pack. The receivers of the tray pack were pleased with the absence of large bruised areas and pears with lid cuts.

Grapes. Researchers test-shipped grapes in four types of experimental boxes. Two were telescope fiberboard boxes each with a capacity of 20 pounds; one with a 28-pound capacity had fiberboard sides and bottom, wood ends and a paper veneer cover; and one with a capacity of 20 pounds had paper veneer sides and bottoms, wood ends, and a fiberboard cover or no cover. Preliminary work done in the past two years indicated that by using less costly materials such as fiberboard, there was a potential savings of 3 to 5 cents per box of grapes as compared to the conventional pack. Also, the labor costs involved in packing and handling the one layer 20-pound boxes would not be prohibitively higher than those of the conventional pack and presumably would encourage packing only high quality grapes. The one and one-half layer conventional lug box permits packing inferior quality in the bottom of the pack.

Six rail test shipments showed that the experimental boxes performed satisfactorily in protecting the grapes from extensive bruising, although they were not found to be superior to the standard wood box. The fiberboard boxes absorbed moisture and the sides and bottoms bowed, allowing the grapes to settle within the box. The overlaid paper veneer 20-pound tapered lug with wood heads performed well. However, since this box is packed flat the grapes settle considerably during extensive storage periods. This settling is enough to allow the grapes to jostle during shipment and also to give a "slack" appearance to the pack. Trade reaction to all the experimental containers has been mixed but mostly favorable.

Strawberries. Materials and packing labor costs for two experimental moisture-resistant fiberboard flats each containing eight one-quart veneer baskets of strawberries were almost exactly the same as similar costs for the conventional wirebound crate with sixteen one-quart baskets. AMS researchers cooperating with the University of Tennessee found that the experimental pack cost 84.5 cents and the conventional pack 85.0 cents per equivalent 16 quarts of berries. These costs, terminal arrival condition of the berries, and trade reaction to the new pack will be reported in a publication to be issued by the University of Tennessee.

Prunes. One test shipment of Italian prunes packed in fiber-board boxes with polyethylene liners was made late in the 1960 marketing season. The prunes arrived in satisfactory condition and were favorably received by the buyers.

Plans: Work will be continued to develop and evaluate better consumer packages and master shipping containers for apples, pears, peaches, grapes, plums, fresh prunes and cherries. It is planned to emphasize work on shipping containers for peaches, pears, plums, and other soft fruit. Use of shrinkable film for consumer packages looks especially promising. As yet, most of the tests have included but one of the several types of this new film now available. The other types also will be studied.

Publications: Prepackaging California Grapes at Shipping Point. USDA MRR No. 410. Philip W. Hale and Donald R. Stokes. July, 1960.

Evaluation of Shipping Containers for Washington Cherries. USDA MRR No. 426, James B. Fountain and Peter G. Chapogas. Sept. 1960.

Better Packaging for Bigger Sales. Donald R. Stokes, AMS. United Fresh Fruit and Vegetable Association Yearbook: 86. Oct. 1960.

Prepackaging Produce - What's New? - What's Ahead?. Donald R. Stokes, AMS. Paper presented before Canadian Fruit Wholesaler's Association, Quebec, Canada. Feb. 8-10, 1960. Mimeo.

Peach Packaging Trends. Donald R. Stokes, AMS. Paper before National Peach Council, Washington, D. C. Feb. 23, 1960. Mimeo.

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Produce Packaging Trends in the 60's. Donald R. Stokes, AMS. Paper before Merchandising and Management Conference of United Fresh Fruit and Vegetable Association, Chicago, Aug. 22, 1960. Mimeo.

Prepackaging Fresh Fruits and Vegetables. Thomas D. Smith, AMS. Agricultural Marketing, November 1959.

Prepackaging Fresh Fruits and Vegetables. Donald R. Stokes, AMS. Yearbook of Texas Citrus and Vegetable Growers and Shippers: 91. Oct. 1960.

12. PALLET CONTAINERS FOR TRANSPORTATION OF APPLES AND PEARS TF, FS

Problem: An increasing number and quantity of fruits and vegetables being prepackaged at the terminal market level, which means in effect they are being packaged twice, once in shipping containers in the production area and again the distribution centers. More information is needed on the use of pallet containers with capacities of from 500 to 2,200 lbs. which can be filled, dumped and handled automatically for shipment of various fruits and vegetables. Large pallet containers are now in limited use for shipment of apples and pears to juicing and processing plants, some of which are located at considerable distances from the producing areas. Use of pallet containers may reduce container, packing and handling costs for fruit for the fresh market, as well as savings in freight and protective service costs.

Program: This long term economic-engineering program covers the development and testing of pallet containers for the transportation of various commodities. It involves container design, laboratory and shipping tests, and analysis of commodity damage and comparative costs. Part of this research on use of pallet containers in fruit marketing is conducted by engineering firms under contract with the Department. One of these contracts is discussed under Improved Methods, Equipment, Plant Layout, and Design for Handling, Packing and Storage of Apples. Another with the Fruit Industries Research and Engineering Foundation is discussed under "Progress" in the following paragraph. The remainder of this work is conducted from Washington, D. C. and Orlando, Florida by AMS research workers in cooperation with the Forest Products Laboratory, container manufacturers, shippers, receiver-prepackagers, and transportation agencies. It involves about 3 professional man-years annually.

Progress: Work under a research contract with Fruit Industries Research and Engineering Foundation, which provided for development, testing, and evaluation of 8 different designs of pallet containers for transportation of apples to terminal market prepackaging plants has been completed. The contractor's report on this research is now being reviewed for publication. Non-expendable, or reusable, semi-expendable and expendable designs were included in this study; however, the major emphasis was placed on light-weight, expendable designs because of the influence of tare weight on freight costs and costs of return of non-expendable designs for reuse.

Fruit bruising studies showed that apples shipped by rail and truck in pallet containers from Washington State to Minnesota carried well with only moderate bruising. Time studies of loading, unloading, and related pre-shipment and post-shipment handling disclosed significant savings in labor requirements. Other substantial economies in packing, labor, and container material costs were also found in this study. Container costs of some designs of pallet containers

per lb. of fruit are estimated to be about half as much as for standard containers, trays and liners.

Some work was also done on the development of loading and handling methods and equipment best suited to the expendable designs. All designs developed and tested in this study are interchangeable between rail and truck shipments.

Work at the Forest Products Laboratory (FS) to obtain fundamental data relative to pallet design and manufacture for use by shippers and manufacturers, and for development of a rational method of pallet design, included a number of studies that will aid in resolving broad problems in use of pallet containers that may apply not only to deciduous fruits but also to other agricultural commodities. These included development of a method for calculating the load-carrying capacity of top deck boards of three-stringer general-purpose pallets and incorporation into a simple circular calculator; determination by test of the desirable construction features of apple harvesting wood bin pallets which showed that for 10 styles tested in simulated weathering and rough-handling three performed well, four were acceptable, and three failed in test. It appeared that vertical sideboards, rather than large triangular corner posts, and many assembly nails are desirable features. In cooperation with AMS, eight designs of pallet boxes for shipping apples and citrus fruits to market in bulk were reviewed and changes proposed. A Wood Pallet Promotion Clinic was held in September 1959.

Plans: Additional shipping tests with some recently developed designs of expendable pallet containers will be made by TF with apples and pears during the 1960-61 shipping season. Publication of an interim report on this work is planned during the coming year.

The Forest Products Laboratory plans to conduct simulated weathering and rough handling tests on at least 2 more of each of 10 styles of wood bin pallets, including effects of water-repellent treatments. Observation and participation in shipping tests of apples and citrus fruits in bulk will be continued, along with design of realistic tests to simulate the stresses and impacts of actual use. This should lead to useful information applicable to similar commodities. Effort will be made to develop a lateral-impact test for pallet fasteners that will simulate stresses imposed by ordinary rough handling, and compare pallet joints made with machine-driven nails to those made with hand-driven nails.

Publications: Bin Pallets for Agricultural Products. T. B. Heebink. USDA FPL Report No. 2115, June 1958.

Load-Carrying Capacity of Deck Boards for General-Purpose Pallets. T. B. Heebink. USDA FPL Report No. 2153, August 1959.

Survey of Wood Bin Pallets Used for Harvesting and Storing Apples. T. B. Heebink. Northwest Wholesale, Inc., Wenatchee, Washington. January 1959.

Rugged Tests for Bins. T. B. Heebink. Produce Marketing, March, 1960.

Preservatives for Wood Pallets. J. O. Blew, Jr. FPL Report No. 216, October 1959.

13. IMPROVED LOADING METHODS FOR SHIPMENT OF DECIDUOUS FRUIT TF

Problem: Increasing freight, protective service, and labor costs, mounting losses from spoilage, damage and reduced shelf life because of ineffective refrigeration and ventilation during transportation have resulted in substantial losses to shippers, receivers, and carriers and greatly increased marketing costs for many agricultural products in recent years. More efficient loading methods that can be used with little or no additional cost to shippers can provide better protection for containers and products, facilitate better refrigeration and ventilation during transit, more efficient pre-shipment and post-shipment handling methods and more effective use of available loading space in the transportation vehicles, leading to reduced per-package transportation, refrigeration and handling costs.

Program: This long-term study involves test shipments by rail and truck from various producing areas throughout the country to different terminal markets to develop and test new loading patterns, load securing equipment, measurement of container and product damage, air velocity, temperature differentials, and labor requirements for loading and unloading. It is carried out from Washington, D. C. and Orlando, Florida with the informal cooperation of shippers, receivers, railroads, truck lines, container and loading equipment manufacturers, State experiment stations and other interest groups and involves about one professional Federal man-year annually.

Progress: The work begun during the 1958 season with peach shipments from Georgia and South Carolina to northern markets to determine if the alternately inverted loading pattern could be effectively used to increase the density of the loads in truck shipments to reduce per-package transportation and refrigeration costs was completed during the 1959 season. During the year the test data were analyzed and a report prepared for publication. The results of this research showed that loads could be substantially increased by using the new load pattern instead of the conventional upright load. The new loading method involves no additional labor or material costs for shippers or truckers.

Apples: Research to develop better loading methods to reduce damage and improve refrigeration in truck shipments of apples in

fiberboard boxes was completed during the year. About 60 test shipments of McIntosh and several other varieties of apples from Massachusetts and Maine to Florida were studied during the 1958-59 and 1959-60 seasons. Controlled tests with the new "air channel load" showed that this pattern, used in conjunction with an adjustable end gate and load-locking devices at the rear of the load, was effective in promoting better refrigeration and in reducing transit damage as compared to the conventional load pattern with no continuous ventilation channels. During the 1959-60 shipping season, emphasis was placed on testing the effectiveness of different kinds of adhesives and frictionizing agents in preventing container movement and blocking of refrigeration channels during transit. Use of the new loading method will involve little or no increase in cost for the shipper or trucker.

Plans: The research on loading methods for peaches in baskets has been completed and the report on this work published. Field work and analysis of the data on improved loading methods for truck shipments of apples in fiberboard containers has been completed and the report on this research is being reviewed for publication. No further research on these problems is planned.

Publications: Better Loading Methods for Truck Shipments of Peaches in Tub-Type Baskets. Thomas H. Camp. USDA-MRR No. 420, August 1960.

14. QUALITY STUDIES

MQ

Problem: Reliable information is needed on the effects of new storage containers and packaging materials with respect to protection of fruit and nuts from physical damage, extension of market life, and reduction of wastage from pathological and physiological disorders.

Program: A long term program to determine suitability of various containers and packaging materials from the standpoint of moisture retention, atmosphere modification, cooling rate, protection from bruising, and storage needs with work conducted at Beltsville and the Wenatchee, Washington and Fresno, California field laboratories and involving about three professional Federal man-years annually plus contract work at the Oregon Experiment Station to investigate core browning of pears.

Shipping containers for peaches. Hydrocooling rates and shipping quality of peaches were determined in two types of waterproofed cartons and in standard 3/4-bushel baskets. Considerably less bruising occurred in cartons than in baskets, particularly at the bottom of stacks. An average of 12 percent of the peaches in baskets at various levels in a stack were bruised on arrival at market as compared to 5 percent in cartons. Decay was about the same in baskets and cartons. With hydrocooling water at approximately 36° F., peaches in baskets and cartons cooled from about 82° to 45° in 15 minutes. The cooling

rate was about the same in baskets and cartons. After hydrocooling and a 25-hour truck transit period from South Carolina to Baltimore, the single wall, waterproofed, corrugated board type of carton was soggy and poor in appearance. The sides and ends of the carton were bulged $\frac{1}{2}$ to $\frac{3}{4}$ of an inch. The double wall, waterproofed, corrugated board type arrived at market in good condition except at the bottom of stacks where some "rolling" of the sides occurred. After standing in a stack for 4 days at 70° F., the single wall carton was in very poor condition while the double wall carton had deteriorated very little from its arrival condition.

Poly Liners for Golden Delicious Apples. A report covering 5-years data on storage of Golden Delicious apples in polyethylene-lined boxes was submitted for publication. Film-liners were beneficial for preventing weight loss and shriveling of this variety during storage. Commercial use is expanding in the East.

Controlled-atmosphere storage vs. film liners for apples. A second seasons' data were obtained on the effect of atmospheres of 0, 3, and 5 percent CO₂ with 3 and 5 percent O₂ on Jonathan, Golden Delicious and Red Delicious apples. Results were very similar to those reported last year. Jonathan Spot occurred only on Jonathans stored in air or in C. A. Atmospheres lacking CO₂. In these treatments 15 to 30 percent of the fruit had Jonathan Spot after 8 month's storage. There was none on fruit in sealed film liners. Core browning occurred in 5 percent of the Jonathans stored in atmospheres with 5 percent CO₂. Scald on Red Delicious and Jonathans was more severe in sealed polyethylene liners than in air, but less on Golden Delicious. There was less scald on fruit in C.A. chambers than on check fruit in air. Generally apples stored in C.A. chambers containing 3 to 5 percent CO₂ were also 0.5 to 1.0 pound firmer than fruit stored in either air, poly liners, or C.A. chambers lacking CO₂.

Film permeability requirements for packaging. Studies on film permeability (CO₂ and O₂) requirements for 20 varieties of apples have been completed and a preliminary report prepared for publication. Water vapor permeabilities should not exceed 0.4 of the permeability required for diffusion of the CO₂ released by the produce.

Film liners and bin liners for California apples. Processing apples stored in polyethylene-coated bin liners maintained quality better and could be stored longer than fruit in conventional storage without liners. This method of storage also costs less than conventional C.A. storage. Thirty bushels of Yellow Newtown apples stored for 29 weeks at 36° F. in a liner ventilated with two 1/8-inch holes showed no carbon dioxide injury (atmosphere, 8.1 percent CO₂ and 12.1 percent O₂) and were much greener and firmer than fruit in a comparable check lot. When the liner was ventilated with only one

hole, the atmosphere averaged 11.8 percent CO₂ and 6.6 percent O₂, and almost 21 percent of the fruit were injured. Storage at 36° resulted in 33 to 48 percent internal browning (low temperature injury), but the browning was slight and of no commercial significance to processors.

Bellflower apples stored for 24 weeks at 36° F. in a bin liner ventilated with one 1/8-inch hole were firmer and greener than fruit stored in a liner with two holes. Atmosphere in the liner with one hole averaged 8.6 percent CO₂ and 11.2 percent O₂ and that in the liner with two holes averaged 6.9 and 13.7 percent respectively. Only about 3 percent carbon dioxide injury developed in fruit held in the liner with one hole. Fruit from the bin with the two-hole liner had a slight amount of scald.

Dual-temperature storage experiments with Yellow Newtown apples, in which the fruit was first stored at 40° and later at 32° F. were inconclusive due to a malfunctioning of the refrigeration system. However, fruits packed in polyethylene liners vented with 12 pin holes were firmer and greener than fruit stored without liners. Fruit held continuously at 40° for 5 months in liners was completely free of internal browning and only slightly less green than fruit stored without liners for 10 weeks at 40° before transfer to 32°. Fruit had to be held at least 10 weeks at 40° before storage at 32° in order to reduce internal browning.

Brown core in Western pears stored in film liners and controlled atmospheres. Studies were continued at Wenatchee, Washington on the occurrence of brown core of Anjou pears in polyethylene liners and the effect of maturity and type of growing season on its development. The stabilized level of carbon dioxide averaged 4.5 percent at 31° F. in the sealed 1.5 mil polyethylene liners, and 1.8 in the multiperforated liners. An insignificant amount of brown core developed in the fruit that was not in polyethylene and in perforated polyethylene while the percentages of fruit with brown core from the sealed polyethylene liners varied from 37 percent in the early picked fruit to 71 percent in the late picking. The disorder was generally slight and confined to the core area in the early picking, while much of it was severe and extended into the flesh in the later picking. This confirmed earlier observations that late picked pears of advanced maturity are much more likely to develop brown core in sealed polyethylene than less mature fruits.

In studies at Corvallis, Oregon, Anjou pears of three maturities cooled at different rates at various intervals following harvest and stored in modified atmospheres with 3 to 5 percent CO₂ and 5 to 15 percent O₂. Fruit maturity at harvest was the most important factor in brown-core susceptibility. None of the early-picked fruits and

relatively few of the mid-season-picked fruits developed brown core when stored at 31° F. until March. Delayed storage and slow cooling increased brown core somewhat but even 6 days delay between harvest and storage caused only slight brown core in pears harvested at proper maturity. Analyses of organic acid in brown-core tissue showed these tissues to be lower than normal in total acidity, but injured tissue was high in succinic acid, which is very low or absent in normal tissue.

Film box liners for California Bartlett pears. Large-size Bartlett pears grown in California are commonly stored at 31° F. in L/A lugs with polyethylene liners for later intrastate marketing. This large fruit is more susceptible to storage disorders than smaller fruit. The modification of the atmosphere within the liners extends the storage life, but also influences the development of cavity formation and brown core and core break-down. The degree of atmosphere modification within the liners can be partially controlled by various perforations. Liners were either sealed or perforated with 5 pin holes, 10 pin holes, or one 3/16-inch hole.

After 3 months storage, levels of carbon dioxide and oxygen in the atmosphere were respectively 4.6 and 7.5 percent in the sealed liner, 3.8 and 15.4 percent in the liner with 5 pin holes, 3.4 and 16.7 percent in the liner with 10 pin holes, and 2.6 and 18.3 percent in the liner with a single 3/16-inch hole. Most of the fruit ripened with high dessert quality, but flesh cavities or brown core were found in 0.2, 4, and 6 percent of the fruit held in the respective liners. Fruit in the check lots (without liners) or that in the sealed liners was not injured, but fruit in the perforated liners was injured in inverse proportion to the degree of atmosphere modification. These results suggest that injury under modified atmospheres may be affected by other unknown factors. When ripened at 70° F. after 3 months storage, core break-down usually associated with senescence developed in 5 percent of the check fruit, but there was none in the fruit packed in liners.

After 5 months storage levels of carbon dioxide and oxygen in the atmosphere of the sealed liners or those perforated with 5 or 10 pin holes or one 3/16-inch hole were 4.8 and 6.9, 3.8 and 13.6, 3.5 and 16.4, and 2.7 and 18.1 percent, respectively. Fruit stored in the liners ripened to fair quality, but the check lots had poor texture (grittiness) and flavor when ripened. Flesh cavities or brown core were found in 2, 4, and 6 percent of the fruit held in the respective liners. Core breakdown developed in 67 percent of the check fruit when ripened and in 0, 12, 28, and 34 percent of the fruit in the respective liners.

Plans: Evaluation of film liners for apples is largely completed and the findings submitted for publication. A final report on

packaging-film permeabilities for apples has been submitted for publication. Similar studies to develop packaging film requirements of pears and possibly other fruits and vegetables are contemplated. Controlled-atmosphere storage studies will be extended to include California-grown Delicious apples. A cooperating apple processor plans to make further use of bin liners for Yellow Newtown apples and tests to determine the proper amount of ventilation for these liners will continue. Tests are planned to use bisulfite-silica gel preparations in perforated and sealed polyethylene liners for stored table grapes. Studies on brown core of pears in film liners will continue with emphasis on the relation of fruit maturity, seasonal weather, and storage atmosphere on the occurrence of the disorder. Additional tests with peaches are planned to compare the shipping strength of waterproofed corrugated cartons of various designs following hydrocooling. Results of cooling studies on the effect of perforated trays and polyethylene liners in corrugated cartons for fruit are being tabulated and a report will be prepared for publication.

Publications: Effect of Various Consumer Baskets, Film Wraps, and Crate Liners on Quality of Strawberries. R. E. Anderson and R. E. Hardenburg. Proc. Amer. Soc. Hort. Sci. 75: 394-400. 1959.

E. Equipment, Facilities, Methods and Firm Efficiency

15. IMPROVED METHODS, EQUIPMENT, PLANT LAYOUT, AND DESIGN FOR HANDLING, PACKING AND STORAGE OF APPLES AND OTHER TREE FRUITS TF

Problem: There is a need for more efficient work methods, techniques, devices, equipment, and facilities for the precooling, storing, handling, and preparation for market of apples and other tree fruits at concentration and shipping points so as to increase the efficiency of labor, prolong storage and shelf life of the fruit, and reduce bruises and injuries.

Program: A long-range program involving engineering-economic research covering the development of improved precooling, handling, storing, and packing methods, equipment, and facilities, carried on by the Wenatchee, Washington and Athens, Georgia field offices and by the Washington office, in both laboratory and commercially-owned facilities in the Pacific Northwest, New York - New England, Appalachian, Georgia and Michigan areas, in cooperation with the Washington, West Virginia, Maine, Georgia, and Michigan Agricultural Experiment Stations; the New York State Department of Agriculture, and the Market Quality Research Division, AMS, at a rate of approximately 3 Federal professional man-years annually. Contract with Fruit Industries Research Foundation, Yakima, Washington

covering development and testing of pallet boxes and auxiliary equipment.

Progress: Storage Designs. Recently, a large number of small apple storage houses have been built in the Pacific Northwest using steel construction. To evaluate the ability of these structures to maintain proper storage environments and to determine the effectiveness of their structural components, thermocouples were installed in the floor, walls, and ceiling of one of these structures to obtain temperature readings and obtain data comparable to that published for conventional types of storages in the report, "Heat Leakage Through Floors, Walls, and Ceiling of Apple Storages." About 60 percent of the manuscript, "Layouts and Designs for Apple Packing and Storage Houses," was completed. During the report period 10 additional sets of plans and specifications for apple storage and packinhouses of three different sizes were distributed through a commercial blueprint firm to 7 firms and individuals.

CA Storage of Apples. Delicious variety apples held in the controlled atmosphere (C.A.) rooms at the Wenatchee laboratory, at 3.0 percent oxygen and 0.5 percent or less of carbon dioxide averaged from 1 to 2 pounds firmer than check fruit held in regular cold storage rooms at 31° F. Studies conducted jointly with the Market Quality Research Division showed that the fruit was acid in comparison to the check fruit. In some of the commercial C.A. storages it was found that the apples had a tendency to take on flavors from the wood storage pallet boxes or from other treatments given the rooms before the apples were placed in storage. In some cases this flavor was very objectional, but decreased progressively and even disappeared when the apples from C.A. storage were held in regular cold storage from two weeks to 30 days.

Room Cooling of Fruit in Fiber Board Boxes. Cooling tests were run on apples packed in tray- and cell-pack cartons in the AMS laboratory at Wenatchee, Washington and in one commercial storage. The Market Quality Research Division cooperated in this study. The half-cooling time for tray-packed apples was 26½ hours and for cell-pack 24 hours; as compared with 14.4 hours for apples packed in standard wood boxes. Using the cooling time of the standard wood box as 100, the half-cooling time of cell-pack fruit was 167 and the tray-pack fruit cooling time was 184. Additional laboratory tests of five different tray-packed fiberboard boxes included: (1) Nonvented box; (2) standard vented box -- 2 holes ½" x 1" in each end of box; (3) enlarged vents - 2 holes 1¼" x 2" in each end of box, (5) times the area of vents in standard vented box); (4) enlarged vents sealed with polyethylene; and (5) enlarged vents with each layer of fruit separated by a layer of polyethylene. Only the fruit in boxes with

the enlarged vents (3), cooled significantly faster than fruit in any of the other boxes. The mean cooling coefficient for this box was 0.03810 as compared with 0.02765 for the nonvented box; indicating an increased cooling rate of about 25 percent. However, in vented boxes, the variation in cooling rate was greater between various locations within the box than it was within a nonvented box. In comparing the cooling rates of fruit located in the center of a large-vented and non-vented boxes, there was a difference of only approximately 16 percent. That is, if 6 days were required for the center apples to cool in a non-vented box (under a given set of conditions) fruit in a box with vents enlarged 5 times over the standard opening would cool to the same point in approximately 5 days. These tests indicate that air circulation probably occurs from bottom to top at ends of the box when vents are located at the bottom and top of the box. The movement does not become of significant importance, however, unless the vents are enlarged from the present $\frac{1}{2}$ square inch area in the standard vented box. With vents of $2\frac{1}{2}$ square inches, there was also indication of significant air movement from one end of the box to the other, but only in the tray of fruit in line with the vents near the bottom and top of the box. There was no indication of a significant movement of air throughout the box.

A study of the cooling rate of packed cherries stacked on pallets in the chimney-stack pattern (an opening is left down through the center of the pallet load) was made. The results showed that the cooling rate of fruit in this stacking pattern was very poor and one firm has abandoned its use for a pattern that will allow the cooling air to circulate freely about the stacked fruit,

A manuscript on "Room Cooling and Storage of Apples and Pears" was completed for Department publication.

Precooling Fruit for Storing and Shipping Apples and Peaches.

Tests of the hydrocooling of apples prior to storage were initiated in the Pacific Northwest during the fall of 1959. For apples that were packed in cell-type fiberboard containers after cooling the preliminary results shows promise of prolonging storage life. Because of the lateness of getting the equipment operating the results were inconclusive.

In the Southeast, laboratory tests were conducted to determine the values of effective thermal diffusivity and conductivity of whole specimens of peaches of the Dixie Gem, Hale Haven, Red Haven, and Elberta varieties. These basic data will provide guidelines to designers and operators of precooling systems for determining the maximum cooling rates possible for peaches of various sizes at various cooling medium temperatures. Laboratory tests also were

initiated to determine the thermal conductivity of the separate components of peaches. Progress was limited to the development of test procedures and calibration of apparatus and instrumentation. In a pilot-scale hydrocooler, tests were carried out to compare cooling rates of packages or containers of peaches using various treatments. Surface coefficients of heat transfer were estimated.

Handling and Packing Apples. A manuscript, "Apple Handling and Packing in the Appalachian Area," was completed and submitted for Department publication. It points out the value of labor-saving devices and methods, and indicates that by combining the most efficient handling and packing methods observed it is possible, at a volume of 50,000 crates annually, to effect a saving of nearly \$5,000 per year over the least efficient combination of methods. At an annual volume of 100,000 crates the possible saving equals \$7,400 and at 200,000 crates, \$12,000.

An improved work station for manually sorting, sizing, and packing McIntosh apples was installed and tested in a commercial apple packing plant in Maine. This work station, which can be made from available material in existing stations at nominal cost, permitted an increase of 10 percent in the number of cartons packed out. Additional data were obtained for a comparative analysis of packing lines used in the Northeast. Using the experimental packing line, now installed at Belding, Michigan, test lots of McIntosh apples were sorted, sized, and then placed in C.A. storage along with a check lot of orchard-run fruit. Results of these "sorting and sizing before storage" tests indicate that a number of very serious problems must first be overcome before this procedure can be adopted commercially for McIntosh apples. The most obvious is the need for the development of a box filler which handles the fruit more gently. Further checks may be necessary to verify these results.

Pallet boxes. The research contact with Fruit Industries Engineering Foundation covering the designing and testing of pallet boxes and auxiliary equipment for handling apples was completed in December 1959. Some of the more significant findings resulting from this research are: (1) Fruit can be cooled more rapidly in pallet boxes having 8 to 11 percent free air space in sides and/or bottom than in palletized standard boxes, therefore, extending the storage life of the fruit 10 or more days; (2) use of pallet boxes in preference to standard boxes permits 20 percent more fruit to be stored in the same space; (3) emptying pallet boxes by immersing them and permitting the fruit to float out causes the least injury to the fruit of all dumping or emptying methods now known; (4) immersion-type emptying coupled with the automatic box filler developed under this contract brings nearer to reality the feasibility of sizing and sorting fruit before storage;

and (5) with sizing and sorting, performed before storage, the small fruit, culls, and other unmarketable fruit can be removed and the storage operator will have an up-to-date inventory of saleable fruit which will permit a better marketing program, make more storage space available for good fruit, and permit him to increase his business volume without expanding his storage facility. It is estimated that total savings to the apple industry resulting from the proper use of the findings under this contract should exceed \$2,000,000 annually.

A patent application has been submitted on the pallet box filler developed under the contract project. However, later information obtained on immersion-type emptying (or dumping) will do much to bring about private interest in developing equipment employing this principle.

A manuscript, "Cooling Rates of Apples in Pallet Boxes" has been prepared for publication by the Department.

Motion Pictures. Two prints each of the motion picture, "Handling and Storing Apples in Pallet Boxes," were placed on file at the film libraries at Cornell University, University of Illinois, and Colorado State University. From January 1 to June 20, 1960 there were 42 showings of the film to a combined audience of about 1,800 persons. Reports from these three film libraries show that during the year ended June 30, 1960 the motion pictures "Apple Handling Methods" was shown 28 times to a total audience of 1,086 and "Apple Packing Methods" was shown 32 times to 1,258 persons.

Plans: Studies will be made of the air flow pattern in a newly constructed reversed air flow storage. The cooling rate of apples in pallet boxes in this storage will be determined and compared with the rate in standard type storages. Temperature readings will be taken by means of the thermocouples installed in the storage using steel construction and the data will be evaluated and, if results warrant, published in an interim report. Additional cooling studies will be made on the effect of perforated trays and polyethylene liners in the fiberboard containers. These data will be tabulated, analyzed, and a manuscript prepared covering these and earlier studies. A series of tests on the cooling rate of apples in various types of containers will be conducted using air pulsation to vary the static air pressure in a storage room.

Work on C.A. storage will be centered primarily on observing how well the present C.A. rooms stand up under seasonal operation. Various methods used for scrubbing the CO₂ from the storage atmosphere will be studied and compared to determine the most feasible method to use in the Pacific Northwest.

Additional studies will be made in the Pacific Northwest of both cell- and tray-packed apples and of apples stored in pallet boxes to determine the possible advantages of hydrocooling fruit before storage. Temperature tests also will be run on field-run fruit hydrocooled before it is packed and stored to determine its storage life.

Field studies will be made to complete data for a comparative analysis of apple packing lines in the Northwest. These data will be analyzed and a report prepared presenting costs of packing by 4 types of packing lines. Use of pallet boxes for McIntosh apples will be investigated; also, methods and equipment for dumping from such boxes will be studied. Time studies will be made of the different operations involving the use of the experimental packing line now installed at Belding, Michigan. If time permits, a further study will be made of "sorting and sizing before storage."

In connection with pallet box research effort will be devoted primarily to preparing and editing results of the contract research for publication.

The manuscripts, "Room Cooling and Storage of Apples and Pears," "Layout and Design of Apple Packing and Storage Houses," "Cooling Rates of Apples in Pallet Boxes," "Apple Handling and Packing Methods in the Appalachian Area," will be put in final form and submitted for Department clearance and publications.

Publications: An Improved Work Station for Packing Apples by Hand. Stanley W. Burt. USDA, Agricultural Marketing. July 1960.

An Improved Work Station for the Manual Sorting, Sizing, and Packing of Apples. Frederick Perkins and Stanley W. Burt. Maine Agricultural Experiment Station Bulletin. September 1960.

An Experimental Packing Line for McIntosh Apples. Stanley W. Burt. Paper presented to the Maine State Pomological Society, Lewiston, Maine, January 21, 1960. Published in the Annual Report of the Maine State Pomological Society, 1960.

Research Developments in the Use of Pallet Boxes for Handling and Storing Produce. Joseph F. Herrick, Jr. Speech at the 1959 National Market Service Workshop, Purdue University, West Lafayette, Indiana, November 17-19, 1959. Published in "Accomplishments in Marketing Through Service Programs," AMS-388, July 1960.

A New Automatic Pallet Box Filler for Apples. Joseph F. Herrick, Jr. USDA, Agricultural Marketing. May 1960.

Mechanical Filler for Filling Pallet Boxes. Joseph F. Herrick, Jr. Better Fruit, June 1960.

F. Costs, Margins, and Organization of the Marketing System

16. CHANGES IN METHODS OF MARKETING

ME

Problem: Deciduous Fruit and Tree Nut industry leaders need more accurate information on the changes taking place in wholesale markets for fruits and nuts to evaluate the impacts of these changes on the industry and to assist in making decisions and recommendations for adjustments to meet these changes.

Program: A 3 - 4 year research program involving about four professional Federal man-years annually, in cooperation with the Agricultural Experiment Stations in Wisconsin, West Virginia, Kentucky, Maine, Montana, Nebraska, New York, Utah, New Mexico, Louisiana, Arkansas, South Carolina, Oklahoma, and Minnesota, and through contract studies in the San Francisco market area by the University of California, Berkeley, California, and in the Pittsburgh market by Midwest Research Institute, Kansas City, Missouri.

Progress: Direct buying by corporate and voluntary chainstores has increased markedly in the postwar years as many more chains grew to a size which made it attractive to them. It can be expected to continue to increase as other corporate and voluntary chains grow to this size. This will mean an increased demand for more uniform products. The size of the lot purchased by individual organizations will increase, on the average. It will be increasingly difficult to dispose of variable lots, small lots, and lots of odd size, grade, color, etc. This may mean increasing emphasis on large packing and shipping operations which can put up uniform lots which will meet the specifications of some part of the chainstore market. Markets may tend to become more segmented as more direct buyers line up a small number of shippers with whom they deal regularly. Volume control will become more important, as the market for supplies which cannot be sold to direct buyers shrinks, and the effect of each additional carload added to or withdrawn from this market will become more pronounced. Wide swings in supply may cause wider swings in price than formerly and it will be more difficult to clean up supplies in a market because the number of buyers will have declined.

Plans: Fieldwork has been completed for a study of the present status and organization of 52 wholesale fruit and vegetable markets throughout the country. This information will provide the basis for description of the structure of wholesale markets and an analysis of the role of terminal markets in the years ahead.

Publications: Chainstore Merchandising and Procurement Practices. The Changing Retail Market for Fresh Fruits and Vegetables. William E. Folz and Alden C. Manchester, USDA Marketing Research Report No. 417, July 1960.

17. INTERREGIONAL COMPETITION IN PRODUCTION AND MARKETING OF
WESTERN FROZEN FOODS

ME

Problem: Strawberry growers and processors of frozen strawberries wish to determine the present competitive position of the Western Region with other areas of the country in order to make their long range plans.

Program: This 5 years cooperative program of basic research has been conducted in the Western Region in cooperation with the Agricultural Experiment Stations of California and Oregon. It has required 2 professional man-years per year of Federal personnel.

Progress: Studies of interregional competition have provided useful guides for the future development of the frozen strawberry industry in the Western Region. A study of frozen strawberries indicated that California has a net cost advantage for nearly all of the frozen strawberries in the United States. However, the advantage is slight. While it appears likely that the Pacific Coast states will remain dominant in the frozen strawberry industry, it appears unlikely that California will expand to produce substantially more than its present share of the market. Relatively minor shifts in regional costs and returns could greatly modify such adjustments, based on present least cost advantage.

Plans: Work on strawberries has been completed. Similar work on vegetables for freezing will be continued.

Publications: "Regional Location of Production and Distribution of Frozen Strawberries." C. C. Dennis and L. L. Sammet, California AES, Giannini Foundation Report 231, June 1960.

18. COST AND EFFICIENCY IN PACKING DECIDUOUS FRUITS

ME

Problem: Increased competition for the fresh market for deciduous fruits has encouraged growers and marketers to find less expensive methods of packing and marketing their fruit. Information is needed concerning the most efficient methods and equipment currently available.

Program: This program of research has consisted of cost and efficiency studies for the past four years in fresh deciduous fruit packinghouses in the major producing areas and in cooperation with State Experiment Stations and other branches of AMS. It involves 3 to 4 professional Federal man-years per year.

Progress: Peaches - During the 1959 season, studies of costs of packing peaches were undertaken in California and South Carolina. Packing costs for California Red Haven and Early Elberta peaches averaged approximately 70 cents per lug. There was considerable

variation in packing costs, ranging from 65 to 81 cents per lug. Packing materials comprised nearly 60 percent, labor about 25 percent, and overhead expenses about 15 percent of total packing costs. Total packing costs in South Carolina varied inversely with size of the packing plant. For bushel baskets, the predominant container packed, total packing costs averaged \$1.05 in small sheds, \$1.11 in medium size sheds, and \$1.29 in large sheds. Medium and large sheds had higher total costs per container than small sheds because of higher labor and operating costs.

Apples - Packing costs for Appalachian apples could be reduced in most plants through increased automation of the packing process, increased volume, increased length of packing season, and changes in method of paying packers. In smaller plants with short packing seasons of 200 hours and season output of 50,000 tray-pack equivalent units, packing labor and machinery costs for each tray-pack carton could be reduced from 21 to 15 cents by use of the semi-automatic tray packing machine. In larger plants operating over a 1400 hour season and packing 250,000 tray-pack equivalent units, labor and machinery costs per unit would drop from 19 to 12 cents if semi-automatic tray packing machines were introduced into the packing system.

Pears - An analysis of cost reductions possible by shifting from lug-box to bulk bin containers in orchard-to-plant transportation indicates that the relative costs of the two containers depend on the handling method used and the rate and length of haul. For low rates of output and short lengths of haul the lug-box method is cheaper. Bin handling methods result in substantial savings for higher rates of output and longer lengths of haul.

In-plant studies of packing operations indicate that volume-fill cartons are cheaper than the wrap-and-place-pack box in all but the smallest plants. Estimated reduction in combined packing and shipping container costs resulting from shifting to the volume filled carton is equal to \$8.75 per ton of fruit handled in a medium size plant (40,000 pounds per hour). If pears are selling at \$75.00 per ton, these cost savings are significant.

California Deciduous Fruits - An additional study concerning California pears and other deciduous fruits has as its objective the description of recent changes in market structure, industry organization, and operating techniques; and analysis of the impact on the industry of a change such as bulk handling. These findings are expected to further industry recognition and understanding of the problems involved and to aid in adopting and adjusting to changes. Work on this project is in its early stages.

Plans: A summary report comparing costs and methods of the five major peach producing areas will be prepared. This project will be completed in December 1960.

A final report on costs and efficiency in other phases of the apple packing process is being prepared.--This project will be discontinued December 1960.

Work will continue on the handling and transportation phases of the pear study. The level and location of pear production within a major California producing region has been projected to 1970. Costs developed earlier will be used to estimate the optimum number, location and size of the packing facilities for this region in 1970 if the most economical methods of packing and handling were employed.

Publications: "Costs, Methods, and Facilities in Packing South Carolina Peaches, 1959" by W. Fred Chapman, USDA Marketing Research Report No. 425, September 1960.

"Appalachian Apples--Packing Costs and Efficiency." Jules V. Powell, USDA Marketing Research Report 435, October 1960.

"Lugs and Bins for Fruit Handling Between Orchard and Packing Plant." John F. Stollsteimer, California Agriculture, Vol. 14, No. 3, March 1960.

19. ECONOMIC ANALYSIS OF RAISIN MARKETING

ME

Problem: Growers need information to assist them in making the choice between raisin and crush outlets, and both growers and marketing firms need to know more about the effects of marketing programs and practices on prices and returns.

Program: Part of a basic economic analysis of the marketing of dried fruits carried on from field offices in Berkeley and Los Angeles, California, with assistance from the Washington office. The project has required about two professional Federal man-years per year and has been carried out with informal cooperation from the California Agricultural Experiment Station.

Progress: The analysis of raisin and prune marketing has been completed. Prices and returns to both raisin producers and packers have improved substantially as a result of market orders in the industry. Improvement in returns has been associated with decreasing numbers of raisin producers and raisin packers. Producer returns for raisins have moved substantially ahead of returns in competing grape outlets without inducing shifts of grape supplies into the raisin outlet. Two publications are in manuscript form.

Publications: None

Plans: This study has been completed.

20. IMPROVED PRICING METHODS

FCS

Problem: Improved pricing plans and grower payment methods are needed to more accurately reflect changing market requirements back to growers and grower organizations so as to better balance supplies with demand. Changing industry organization and procurement practices required by mass distribution are bringing about more complex product specifications, and has altered pricing techniques which reduce the effectiveness of conventional pricing methods.

Program: This continuing long-range program of applied research, part of which is contributing to the Western Regional Project Wm-38, is conducted in major production areas and involves about one professional Federal man-year annually.

Progress: Current work in this area involves (a) a comparison of returns to growers of selected fruits and vegetables from various grower payment methods, and (b) an analysis of the impact of bargaining associations on the market structure and behavior of the fruit and vegetable processing industry. Neither phase has progressed to a stage where findings can be reported.

Again at the request of growers, a Fourth National Conference on Fruit and Vegetable Bargaining Cooperatives was held in January 1960 at Atlanta, and a proceedings prepared and distributed.

Plans: Work will be continued, and publications are planned on both phases of this study.

Publications: Co-op Grower Payment Methods in a Changing Market. C. B. Markeson. News for Farmer Cooperatives, February 1960.

Some Facts About Fruit and Vegetable Bargaining Cooperatives, W. M. McMillan, FCS Information 11, December 1959.

21. STRUCTURE AND PRACTICES OF THE PECAN INDUSTRY

ME

Problem: Little information is available on the pecan marketing system. The need for research that examines the organizational pattern, the factors affecting prices, and marketing costs is great.

Program: This study will describe and analyze the assembly and distribution of pecans from the farm through the sheller-processor levels. Informal cooperation will be obtained from Agricultural Experiment Stations in the major pecan producing states. Approximately 2.0 man-years of professional time will be required for the duration of the project.

Progress: Work on this project during the year was developmental and has not progressed so that there are findings to report.

Plans: Field work on this project will begin in early spring, 1961, and will consist of interviews with growers, shellers, and processors in the 11 major pecan producing states.

Publications: None

G. Supply, Demand and Price

22. DEMAND, OUTLOOK AND SITUATION ANALYSES FOR DECIDUOUS FRUITS AND TREE NUTS

AEC

Problem: Producers, processors, distributors and consumers need information on past and probable future production and consumption of deciduous fruits and tree nuts and the effects of these and other factors on price.

Program: A continuing statistical analysis of data and preparation of periodic situation and outlook reports, supplemented from time to time with special statistical studies of factors that affect demand and price, using data assembled by census and agricultural estimates and other agencies, carried on at Washington, D. C., and involving approximately 1 professional Federal man-year annually.

Progress: Situation and outlook work has continued with regularly scheduled reports of The Fruit Situation, The Demand and Price Situation, and The National Food Situation. Important trends and changing relationships dealing with production, price, use and consumption of fruit were published as a group of charts in the annual outlook chart book, November 1959.

A special article in The Fruit Situation, August 1960, showed that for the United States as a whole and in the principal apple processing States since 1935, the percentage of apple sales used fresh declined while the percentage processed increased. Apples for canning accounted for much of the increase in processing -- the pack of canned applesauce alone increased 8-fold. Of the 35 pounds (fresh weight equivalent) of fresh and processed apples consumed per capita in 1935, about 93 percent were eaten fresh and 7 percent in processed form. By 1959, when consumption had dropped to 29 pounds, about 75 percent were eaten fresh and 25 percent processed, the latter due mainly to increasing popularity of canned apples, applesauce and apple juice.

A special feature of The Fruit Situation, August 1960, was a set of 7 tables presenting historical series on per capita consumption of individual and broad groups of fresh and processed fruits and tree nuts. Figures for recent years were published in the Supplement for 1959 to Consumption of Food in the United States, Agricultural Handbook No. 62, August 1960.

Demand and price analysis of peaches, relating primarily to California clingstone and Pacific Coast freestone peaches, was continued during the year and is nearing completion. For clingstone peaches the most

important factors with respect to price were total supply of canned California clingstones anticipated at the beginning of the canning season. There was some evidence that carryover stocks were more closely related to price than expected pack. While consumption of canned peaches is related positively to income up to middle income levels, high income consumers tend to use smaller quantities of canned peaches per person. However, on an annual basis, changes in income do not reflect a measurable change in clingstone peach prices. The same was true of supply of competing canned fruits. For freestone peaches, some additional work is necessary to fully evaluate the interactions among prices and utilizations because of substantial changes in utilization trends in recent years.

Plans: Continue regular analyses and the issuance of situation reports; complete the analysis of demand for peaches and prepare a report covering the findings.

Publications: The Fruit Situation, published four times a year, with a comprehensive outlook report in the October issue.

The Demand and Price Situation, monthly, includes a summary on the price situation for fruit.

The National Food Situation, quarterly, includes a summary of supply and consumption of fruit and tree nuts.

Trends in Apple Use and Consumption, Ben H. Pubols, The Fruit Situation (TFS-136), August 1960.

Per Capita Consumption Tables, Ben H. Pubols, The Fruit Situation (TFS-136), August 1960.

H. Foreign Competition and Market Analysis

23. COMPETITION FROM OTHER EXPORTING COUNTRIES--FRESH DECIDUOUS FRUITS

FAS

Problem: Approximately 6 percent of all U. S. fresh deciduous fruit sales are for foreign markets. Knowledge of our competitors' potential and information of foreign markets is essential in maintaining and developing our exports.

Program: This is a continuing long-range project aimed at reporting existing and potential foreign competition. It includes first-hand surveys of competing areas and export markets supplemented by research in Washington. This work involves approximately one professional Federal man-year annually.

Progress: No long-range projects involving surveys of deciduous producing countries were undertaken in 1959-60. However, current information on competing supplies and export market conditions was evaluated.

Plans: A survey of the deciduous fruit storage facilities in Western European markets is planned for 1961. Also, competition studies of the deciduous industries of New Zealand, Australia and South Africa are contemplated.

Publications:

Northern Hemisphere Apple and Pear Crops Down Sharply.
FDAP S-59, October 1, 1959.

Summer Outlook for Apples and Pears. FDAP 1-60, February 1, 1960.

24. COMPETITION FROM OTHER EXPORTING COUNTRIES--CANNED DECIDUOUS
FRUITS

FAS

Problem: Around 7 or 8 percent of the total U. S. canned deciduous fruit pack is exported; most exports are destined to Western European markets. Knowledge of our competitors' potential and information of foreign markets is essential in maintaining and developing our exports.

Program: This is a continuing long-range project aim at reporting existing and potential foreign competition. It includes first-hand surveys of competing areas and export markets supplemented by research in Washington. This work involves one professional Federal man-year annually.

Progress: Conclusion drawn from competition survey completed in 1959-60: (1) Australia and the Union of South Africa rank next to the U. S. in production of canned deciduous fruits. However, unlike the U. S., Australia and South Africa export more than half of their combined output. Australia's canned fruit output appears to be leveling off, but South Africa is in the midst of a program of rapid expansion with substantial production increases recorded from season to season. (2) Spanish canned deciduous fruit production

and exports are increasing. A new can manufacturing plant began production this year, which will eventually replace can manufacturing by each cannery. Packing of fruits in consumer-size cans has begun to replace the traditional large institutional-size cans.

Plans: Surveys of the deciduous canning industries of Italy and Greece are contemplated. The report, Spanish Deciduous Canning Industry, is being prepared for publication.

Publications: The Australian and South African Canned Deciduous Fruit Industries by Frank C. Elliott. USDA FAS M-61, October 1959.

25. COMPETITION FROM OTHER EXPORTING COUNTRIES--DRIED FRUITS FAS

Problem: The United States normally exports about 30 percent of its dried fruit pack. The long-term prospect is that increasing reliance will have to be placed on the export market as U. S. production is expected to rise faster than domestic consumption. Our ability to move increasing quantities of dried fruits into export is affected directly by the volumes of competing supplies from other countries. Therefore, to maintain and develop this export market it is necessary that the potential of competing countries be known.

Program: This is a continuing long-range project aimed at reporting existing and potential foreign competition. It includes first-hand surveys of competing areas and export markets supplemented by research in Washington. This work involves at least one professional Federal man-year annually.

Progress: Conclusions drawn from competition surveys completed in 1959-60: Raisins - (1) Greek raisin production is increasing; this will be directly reflected in increased exports. Quality of Greek raisins is being continuously improved. Improvements in packing methods were also observed; (2) Iranian raisin exports, which increased significantly in recent years, is not likely to show further increases due to production limitations and may have difficulty in maintaining this level due to competitive disadvantages. Some improvements in packing were noted but quality is still lacking in the Iranian raisins.

Prunes. Neither production nor exports of Australian dried prunes is expected to increase significantly in the near future.

Dried Fruit. U. S. dried fruits have enjoyed consumer preference in the export markets because of superior quality and packing. However, competing countries have improved and are continuing to improve the quality of their dried fruit packs to such an extent that price differential and availability will become the major consideration in the importing countries.

Plans: A survey of the dried prune industry of France and re-survey of the dried prune industry of Yugoslavia in 1961. A comprehensive study of the Turkish raisin industry will also be made. The report, The Iranian Raisin Industry, is now being prepared for publication.

Publications: The Greek Raisin Industry by Stanley Mehr. USDA FAS M-75, December 1959.

The Dried Prune Industry of Australia by Cornelius de Goede. USDA FAS M-97, October 1960.

26. COMPETITION FROM OTHER EXPORTING COUNTRIES--TREE NUTS FAS

Problem: In the past, the United States has been a net importer of almonds, walnuts, and filberts. However, with U. S. production of almonds and walnuts increasing it may be necessary to place increasing reliance on the export market. U. S. almond exports have become an important surplus outlet in recent years. Knowledge of the production and export potential of competing countries and market potential of importing countries is essential in developing and maintaining exports as well as maintaining sales against import competition.

Program: This is a continuing long-range project aimed at reporting existing and potential foreign competition. It includes first-hand surveys of competing areas and export markets supplemented by research in Washington. This work involves one professional Federal man-year annually.

Progress: No long-range projects were undertaken in 1959-60; however, foreign production and market developments were kept under surveillance and brief reports on current conditions were issued.

Plans: Competition surveys of the Spanish and Italian almond industries are contemplated in 1961.

Publications: 1959 Almond Crop Sets Record. FN 1-59, October 9, 1959.

1959 Walnut Production Down. FN 2-59 November 30, 1959.

1959 World Filbert Harvest of Average Size. FN 3-59, December 11, 1959.

1960 Mediterranean Almond Harvest Below 1959; Beginning Stocks Large. FN 1-60, July 1, 1960.

World Almond Supplies Down. FN 2-60, October 4, 1960.

